Challenges in Recycling used cooking oil to produce Biodiesel in Polokwane

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Abstract

In response to the ever increasing problems associated with climate change, and greenhouse gas emissions, many countries in the world are developing and adopting climate change resilient policies that support green economy.

Green economy sector in South Africa has not as yet received much expected attention as a key sector to address economic and environmental problems. The use and the production of renewable fuels, such as biodiesel are known to have significant economic and environmental benefits. However, progress in the production of biodiesel is hampered by limits imposed by government on the use of fresh vegetable extracted oils for production of biodiesel, mainly due to challenges on food security; and the impact this will have on food prices.

In recent years recycling has become an important tool to address waste problems; pollution control; and socio-economic problems such as joblessness, poverty and social inequity. Used cooking oil has always been considered waste and an environmental burden. Therefore through technology advancement of recycling, wastes such as used cooking oil have become useful resources for biodiesel production.

This research is about the challenges in recycling used cooking oil to produce biodiesel. The study recommended that in order to address challenges facing sustainability of our environment, and high unemployment rate; small recycling industries such as those operating in Polokwane will need government support such as biodiesel sector policies and regulations, to encourage investment in the biodiesel value chains in a way that will lead to the achievement of green economy goals.

Declaration

I hereby declare that this report is my own, unaided work. It is submitted in partial fulfilment of the requirements for the degree of Master of Management (in the field of Public and Development Management) in the University of Witwatersrand, Johannesburg.

It has not been submitted before for any degree or examination in any other University.

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Humbelani Ramuedzisi

31 March 2016

Dedication

I dedicate this work to my late father Mr Magwala Daniel Ramuedzisi; my mother Mrs Ennie Mavhungu Ramuedzisi. To my wife Mulalo and Son Vha V, I know I have sacrificed our time in order to complete this research. Your unwavering support kept me going and focused. I say thank you.

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I would like to give special thanks to my wife Mulalo for her support during the period of my study and for believing in me. Special thanks my mom and siblings for their words of encouragement.

Not forgetting my supervisor Dr Ivor Sarakinsky for his guidance and advice throughout this Masters work.

I will not forget the encouragement that my late father gave me from my early childhood education saying in Tshivenda “Vhala Bugu!” loosely translated as “you must study very hard!”

Acronyms

IDP	Integrated Development Plan
LEDET	Limpopo Department of Environmental Affairs and Tourism
NDP	National Development Plan of South Africa
UCO	Used Cooking Oil
UN	United Nations
USA	United States of America
WCED	World Commission on Environment and Development

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Chapter 1. Introduction and background

1.1. Introduction

This research has investigated the challenges in recycling used cooking oil to produce biodiesel. Biodiesel is regarded as a renewable biodegradable fuel which is not harmful to the environment and has low carbon emissions (Nas & Berktay, 2007).

The move from sustainable development to a more focused green economy discourse has brought much needed breakthrough into the implementation of sustainable development objectives. The United Nations (UN) conference adopted a policy resolution that foresees sustainability through green economy (Nhamo, 2014).

Green economy has become a way of achieving sustainability by linking economic growth with environmental activities, in such a way that an improved environment and economic growth are intertwined for job creation, poverty reduction, and reduction of social inequity; and at the same time addressing carbon emission problems.

Green economy amongst others encourages the production of renewables such as biodiesel. Many researches have proved that biodiesel is a good alternative fuel to petroleum fuel, due to its low carbon emission. Biodiesel is mainly produced from vegetable oils; studies show that vegetable oils from soya beans and sunflower are the most popular feedstocks for biodiesel production (Pimente & Patzek , 2006). Several studies also show that the first diesel engine was fuelled by vegetable oil (peanut oil).

Regardless of the environmental benefits from renewable fuels produced from vegetable oils, South African government does not support the use of fresh vegetables for the purpose of producing biodiesel, due to socio economic

concerns around the issues of poverty and high food insecurity in the country. The recycling of used cooking oil may solve this problems while providing sustainable and environmentally friendly fuels.

The study used the qualitative approach method, which requires researchers to investigate the identified problem. The semi-structured interview technique was employed to get relevant information on experiences of fast food outlets that are producing used cooking oil on a daily basis; recyclers of used cooking oil; government policy implementers (administrators); and users of biodiesel, in Polokwane municipality in Limpopo province.

This chapter discusses the background of the research to clarify the issues that led to this study. The chapter will also outline the problem statement, the purpose of the research study, and the research questions guiding this study.

1.2. Background

The 2008 global economic crisis was a major turning point for debates around the goals and policies of sustainable development. The UN conference (Rio+) in Rio Je Janeiro on sustainable development in 2012, shifted the focus to green economy with the intention of strengthening interventions to reduce greenhouse gas emissions and carbon footprint in a more focused way of job creation and improved social equality.

Many scholars have argued that humankind survival coexists with the environment, meaning that to achieve sustainable development human beings must, by all means try to maintain the balance between environment; social equity; and economic growth.

1.2.1. Policy framework

With the growing policy debates around issues of green economy and sustainability, South Africa ‘s focus is on reducing greenhouse gas emissions

by developing policies aimed at addressing challenges posed by high emissions; encouraging the use of renewable fuels such as biodiesel; and to adopt other conducive environmental friendly practices.

South Africa encourages the production of renewable fuels (including biodiesel) as a means of unlocking millions of jobs by 2030, as per the National Development Plan (NDP) of South Africa. The NDP highlights issues of environmental sustainability, and the importance of protecting and enhancing environmental assets and natural resources (National Planning Commission, 2012).

There are various policies and strategies that support the implementation of green economy, such as the new growth path which seeks to create millions of decent jobs, reducing poverty and inequality through amongst others, recycling schemes for greening the economy.

The Limpopo Provincial Government looks advanced in the formulation of policies on climate change since they have a green economy plan that aims to create jobs through green economy sector, but so much still needs to be explored (Musyoki, 2012).

South Africa's wastes are regulated in terms of the National Environmental Management Waste Act, 2008 (Act no 59 of 2008), and the National Domestic Waste Collection Regulation Standards. This Act and its regulation provides guidance for municipalities and any other waste producers on the classification and management of waste, as follows: to establish mechanisms and procedure for waste management; prescribe reasonable targets for control and management of wastes; and assign responsibility to waste generators, collectors of waste and managers of wastes. (Department of Environmental Affairs, 2013).

According to the Development Bank of South Africa (DBSA), robust policies and regulations have the potential to attract investment in green projects innovation. According to the DBSA (2011:30) “A stable regulatory and legislative framework would support the financial and market innovations necessary for the implementation of large-scale green projects” (DBSA, 2011). This is the case with regard to the recycling of used cooking oil, because by getting legislations right, a country would attract more investment into the recycling sector, and these has the potential to create more jobs and grow the local economy.

South Africa has some high level policies that shows biodiesel as a future renewable fuel; but little has been done to put biodiesel to a level that could be considered competitive enough to supplement petroleum diesel.

1.2.2. Demographics

Polokwane is situated in the central part of the Limpopo Province. Statistics shows that Polokwane Municipality has an estimated population of about 628 999, with about 178 001 households. Approximately 86 per cent of households have income. Unemployment rate is 32.4 per cent of the population, with the youth unemployment rate at 42 per cent. About 33.7 per cent of households have piped water inside dwelling, meaning that this percentage could be assumed to be connected to the municipality‘s sewage drainage system (Statistics South Africa, 2011).

1.2.3. Global benchmark

Global benchmark shows that the recycling of used cooking oil is a viable source for biodiesel production. The recycling of used cooking oil to produce biodiesel is currently growing in foreign countries such as United States of America (USA), Brazil, China, and Japan (Owolabi , Osiyemi , Amosa , & Ojewum, 2011). However, in South Africa the recycling of used cooking oil for biodiesel production is still at a small scale, as it has not yet gained much more

popularity than it has in other countries. Biodiesel production is happening at a very low scale in three metropolitan areas such as Cape Town, Durban and Johannesburg.

In the USA, it is estimated that about 100 millions of litres of used cooking oil are produced per day; while the estimated total of used cooking oil produced in Canada, European countries and United Kingdom could be approximately 135,000 tons, 700,000-1 million tons, and 200,000 tons of used cooking oil per year respectively (Owolabi , Osiyemi , Amosa , & Ojewum, 2011).

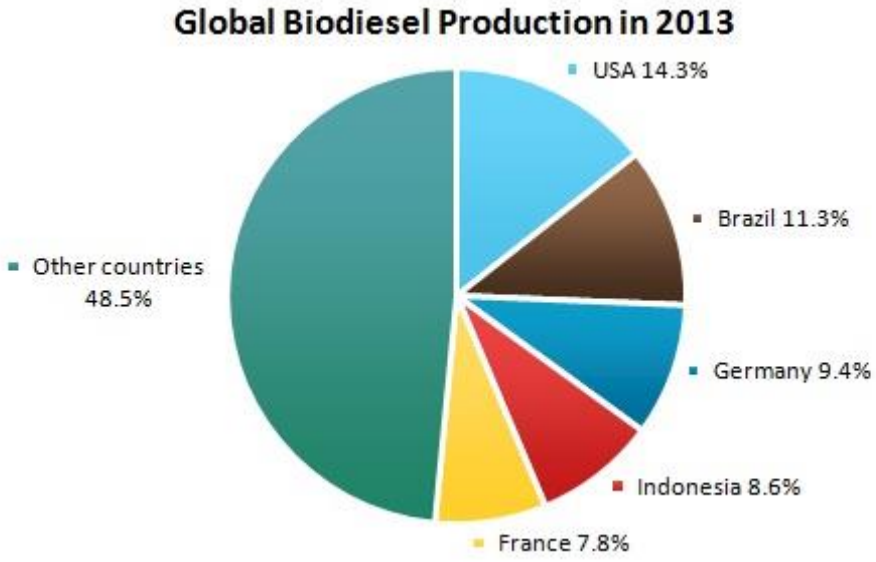


Figure 1: Global Biodiesel Production in 2013

Source: Global-Biodiesel-Production (2013)

Polokwane city is lagging behind with regards to the production of biodiesel; therefore, this research has provided an in-depth knowledge on the opportunities presented by recycling used cooking oil to produce biodiesel and its challenges in Polokwane, Limpopo province.

1.3. Problem Statement

South Africa considers green economy as one of the sectors that has the potential to improve the environment; grow the economy; create employment; reduce carbon emissions; reduce poverty, and social inequality (Borel-Saladin & Turok, 2013) and (Nhamo, 2014).

In a broader context, green economy is viewed as a sector that has brought new policy direction in both developing and developed countries as it attempts to reduce the risks associated with climate change; and a positive shift towards green economy has huge effects in reducing greenhouse gas emissions. But there are concerns about lack of funding and clear policies for sustainable green economy industries in South Africa.

The positive information about the ability of green economy to reduce carbon emissions and to stimulate the creation of local jobs is a point that sets the tone for this research, as there are many opportunities presented by green economy, particularly in the recycling processes; collections and delivery of used cooking oils to various recyclers for production of biodiesel (Borel-Saladin & Turok, 2013).

Large quantities of used cooking oil are disposed-off into the environment on a daily basis by households; fast food outlets and other various food processing businesses in Polokwane. These businesses and households may not be aware of the economic and environmental benefits of recycling used cooking oil instead of disposing-off, for instance through illegal dumping into sewage systems and landfills (Owolabi , Osiyemi , Amosa , & Ojewum, 2011).

There are various policies and regulations in almost all spheres of government that addresses the challenges that are posed by waste in the environment, but the implementation of waste management policies and reduction of greenhouse

gas emissions at provincial and local governments lags behind (Mukonza & Mukonza , 2014). The reduction of emissions can be made possible only with the interference of government at all spheres, with local government developing strategies to work with communities to reduce the environmental risks posed illegal dumping of used cooking oil; and high greenhouse gas emissions.

Various interviews have been conducted in Polokwane municipality to investigate the challenges that seem to be hindering progress with regards to implementation of green economy as a sector, with special focus on the recycling of used cooking oil to produce biodiesel (Mukonza & Mukonza , 2014).

1.4. Purpose Statement

The purpose of this research was to investigate the challenges in recycling used cooking oil to produce Biodiesel in Polokwane, Limpopo Province. The research also focused on determining whether recycling used cooking oil had the potential to create employment and the impact on reducing greenhouse gas emissions.

1.5. Research Questions

The research questions that guided this research study are:

a) What are the economic benefits of recycling used cooking oil to produce biodiesel in Polokwane?
b) How does the reduction of carbon emissions impact on green economy and job creation in Polokwane?
c) What is the current status of policies that regulate full scale production of biodiesel in Polokwane?
d) What are the environmental benefits of using biodiesel in Polokwane?

1.6. Structure of the research

Chapter 1: Introduction to the study

This chapter provides an introduction, and background to the research; and defines its objectives, and problem statement. It also explains the research purpose and research questions to the study.

Chapter 2: Literature review

This chapter provides theory and literature that guides the relevance of this research. The literature discusses various themes linked to the theory on green economy to justify the research topic.

Chapter 3: Research Methodology

This chapter looks at research the methodology adopted to approach research and the strategy that was used to present and analyse data.

Chapter 4: Data presentation

This chapter provides an investigation; deals with the presentation of research data findings; and summarises research findings.

Chapter 5: Data Analysis

This chapter provides an analysis of the challenges in recycling of used cooking oil for biodiesel production in Polokwane. The chapter also deals with the rigorous analysis of research themes and findings

Chapter 6: Findings and recommendations

This chapter analyses the overall findings of the study and makes recommendations for future research where possible.

Chapter 7: Conclusion

This chapter provides the understanding, the judgment, and the recommendations; and then concludes all the findings of the study.

Chapter 2. Literature Review

2.1. Introduction

This literature review used various academic articles related to topics on the recycling of used cooking oil to produce biodiesel; green economy; sustainable development; environmental management; and other related academic fields. The review focused on international and national perspectives in the context of biodiesel production and its implication on sustainable development and green economy.

The review outlined the importance of sustainable development; green economy; advantages and disadvantages of biodiesel; alternative ways of producing biodiesel; biodiesel from used cooking oil, environmental management; agro processing; challenges facing small scale biodiesel producers; and lessons from other countries.

The theories on green economy as an influential part to the recycling of used cooking oil to produce biodiesel was guided by various literatures relative to the topic of the research.

2.2. Theoretical framework

The theory on green economy focuses on knowledge of climate change, greenhouse gas emissions, waste management, renewable fuel and energy, and economic growth. Various scholars agree that climate change has become a global problem which can be addressed through the use of renewable fuels in order to reduce environmental risks posed by greenhouse gas emissions.

Since it is widely regarded as an environmental friendly fuel, Biodiesel is regarded as one of the solutions to reduce greenhouse gas emissions and has significant economic benefits for overall biodiesel production value chain (Gahukar, 2009).

The green economy theory further focuses on turning waste into valuable resources. Used cooking oil has always been considered a waste and an environmental problem, but is now considered a useful resource if recycled into biodiesel. Recycling has become an important alternative of waste management, through its ability to minimise environmental health risks; and for socio economic benefits through job creation, poverty reduction and reduction in social inequality.

2.3. Relationship between sustainable development and green economy

Sustainable development and green economy are considered key discourses influencing policy directions in most countries, including South Africa. Most academics and scholars have conceded in the struggle to develop clear definitions for these discourses; while others accuse the UN of failing to come up with clear definitions for their policies (Walshe, 2013).

As many scholars view sustainable development and green economy as complementary; proponents of green economy suggests that it addresses clear socio economic issues such as poverty eradication; the creation of sustainable jobs; and social inequality than sustainable development which dwells on addressing the environment and social equity; and sustainable growth without clarity on how these three elements would be achieved. (Morgera & Savaresi, 2013).

2.4. Sustainable Development

In the past century economic growth posed tremendous environmental and sustainability concerns due to increased scientific knowledge, technology innovations, and industrialisation which have caused major sustainability threat on people's core existence with the environment, mainly due to ever increasing population; high pollution; poor natural resource conservation; and climate change (Du Pisani, 2006).

According to the World Commission on Environment and Development (1987) as cited in Barbier, (2011:234), sustainable development can be defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Barbier, 2011).

Ross, (2009), argues that sustainable development lacked focus and clarity due to its vague and weak policy focus with conflicting interests; but also provided an alternative, arguing that sustainable development policies may be hammered into shape to the benefit of those interested in its principles.

Nhamo, (2014), argues that the general feeling globally was the slow and poor performance of sustainable development policy, claiming that even developed countries are still struggling to address unemployment and poverty issues (Nhamo, 2014).

Although, sustainable development does not provide clear policy objectives; it offers a wide range of policy framework which various countries had to expand on, in order to prioritise sustainable environment, economic, and social contexts.

2.5. Green Economy

Green economy is relatively a new policy direction adopted by the UN in 2012. Kumar & Kumar, (2011) defines green economy as "a system of economic activities related to the production, distribution and consumption of goods and services which results in improved human well-being over the long term, while not exposing future generations to significant environmental risks or ecological scarcities" (Kumar & Kumar, 2011).

However, Morgera and Saveresi, (2013:p14), claims that green economy does not replace sustainable development (Morgera & Savaresi, 2013); and his claim is supported by Borel-Saladin who argues that green economy came as an intervention to achieve sustainable development, and is not specific on how to

achieve sustainability, but brings promising transformation and improvement to sustainable development (Borel-Saladin & Turok, 2013)

Morgera & Savaresi, (2013), further claims that the discourse on green economy favours the rich and developed countries, this argument is based on the claim that most rich countries emit high greenhouse gases, giving South Korea as an example (Morgera & Savaresi, 2013). However, Nhamo, (2014) provides a useful counter-argument that South Korea is one of the leading countries in green economy policy initiatives; and has incentives and good strategies in green technologies (Nhamo, 2014). This argument is baseless since high emissions are a results of using non-renewable production practices that also happens in poor countries with low economic growth.

The theory of green economy point to the need for proper and strategically crafted policies suitable for public and private investment. National, Provincial and Local government regulations, policies and incentives are key to enable green economy investment potential for the benefit of society (Borel-Saladin & Turok, 2013).

In the South African context, the issue of green economy is seen as a key to achieve both environmental and economic sustainability, and to address high unemployment rate; poverty and social insecurity (Borel-Saladin & Turok, 2013). This means that, more job opportunities will have to be created through public and private investments that focuses on reducing carbon emissions and pollution; fuel efficiency; and protection of biodiversity (Nhamo, 2014).

The argument by Nhamo, (2014), support the main aim of this review, as the review seeks to identify ways of reducing carbon emission, creating jobs and reducing poverty by finding options that will address challenges in recycling used cooking oil to produce biodiesel. It is noticeable that green economy contributes greatly to the reduction of carbon emissions, and greenhouse gases.

2.6. Overview of biodiesel

Biodiesel is defined as a renewable environmental friendly fuel that has the potential to supplement the use of petroleum diesel fuel. (El-Gendy, Abu Amr, & Abdul Azi, 2014). Biodiesel is regarded as a sub-sector of green economy which can contribute towards reducing carbon emission as claimed by its proponents.

The recycling of used cooking oil has been identified as an alternative resource for biodiesel production (Gahukar, 2009). A shift from petroleum diesel to a biodiesel fuel has the potential to benefits both the environment and socio economic issues to achieve green economy goals through job creation; poverty alleviation; and improved social equity (El-Gendy, Abu Amr, & Abdul Azi, 2014).

2.7. Advantages of biodiesel

Biodiesel emit less carbon monoxide and has great environmental advantages than petroleum diesel. Biodiesel production is economically effective as its production process generates glycerol (by-products), which is useful in the manufacturing of glycerine and soap. In this case profits could be made in downstream biodiesel production value chains. (Brandãoa, Penedob , & Pintoc, 2013).

The most important advantage of vegetable oils, is that they are renewable and sustainable compared to petroleum oil which is said to be depleting with time (Utlu, 2007). The recycling of used cooking oil as a resource for biodiesel production also add to the advantages of biodiesel; as this may also help to reduce illegal dumping of used cooking oil, in the municipal sewage drainage systems, and to address environmental degradation.

Generally most researchers conclude that biodiesel production from used cooking oil is inexpensive; economically effective; and safe to the environment and public health.

2.8. Disadvantages of biodiesel

Very few disadvantages have been identified in literature. Some authors argues that the cost of biodiesel is likely to increase in future due to expected demand and lack of vegetable oil during drought years/seasons in the long run. Furthermore, production costs may also cause supply challenges (Utlu, 2007).

The most common disadvantage of biodiesel has been its adaptability in cold weather, as this may affect its combustion level and reduce engine power (Jaakob, Mohammad, Alherbawi, Alam, & Sopian, 2013). However, given the fact that South Africa is located in the warmer sub-Saharan Africa region, this disadvantage is less likely to discourage production of biodiesel in South Africa.

2.9. Common renewable resources of biodiesel production

Vegetable oils have been proved as main sources of diesel production. The first diesel engine was fuelled by peanuts oil (Lin, Cunshan, Vittayapadung, Xiangqian, & Mingdong, 2010). Various plants have been identified as main sources both eatable and non-eatable oils, such as Jatropha oil, sunflower oil, soybean oil, canola oil, cassava oil, palm oil, and others (Ho, Wong, & Chang, 2014).

The preference of biodiesel feedstock depends on the supply and availability. In the European countries, cotton seed oil, soybean oil, sunflower oil, peanut oil and Jatropha oil are major sources of biodiesel production, due to favourable environmental conditions for these plants (Amiguna & Musango, 2011).

Given the above information, recycling used cooking oil, is the preferred alternative to the use of fresh vegetable oils. This alternative may not be so popular in many countries, but is more favourable to the South Africa economy, due to food security challenges.

2.10. Impact of biodiesel production on food security

This section highlight the implications of biodiesel production on food security, and demonstrates the trade-offs that countries may adopt in producing biodiesel, without violating other human rights or the dignity of the poor and food insecure. At a glance there are over a billion people in the world who are said to be food insecure; therefore the production of biodiesel from fresh vegetable oils may not be fair to the hungry (Kullander, 2010).

There are environmental impacts on the large scale production of vegetables for biodiesel production, which include severe soil erosion on arable land, exacerbated by the heavy use of non-organic fertilisers and pesticides which may have an impact on air pollution and climate change (Kullander, 2010).

In South Africa, the use of fresh vegetable oils for biodiesel production is not supported, due to the widening gap between the food secure and the hungry; and its likely impact on food prices. (Azam, Waris, & Nahar, 2010).

The production of sunflower and soybean oils is feasible in both commercial, and small scale farming as food and industrial crops. Therefore increased use of biodiesel is useful to create demand and promote crop production (Amiguna & Musango, 2011).

According to Gustavo, (2010), South Africa's farmers could reap huge harvests if they expand production to accommodate biodiesel and also produce surplus produce for consumption, and to reduce food insecurity (Gustavo, 2010).

Brandãoa, *et al* (2013), indicates that Brazil, has been involved in biodiesel production since 2005, aiming to reduce reliance on petroleum diesel and to reduce carbon emissions. This evolution increased the demand for biodiesel fuel and created more job opportunities in rural Brazil, where most smallholder

farmers are major producers of soybean, which is regarded as a major source of oil for biodiesel production (Brandãoa, Penedob , & Pintoc, 2013).

Although, Jatropha plant is considered the most suitable source of biodiesel, it is currently not an attractive source in most parts of the world, including South Africa, due to its invasive tendencies and high water consumption (Amiguna & Musango, 2011).

Based of the above arguments against the use of crops for biodiesel production, fresh vegetable oils have always been the option, but due to concerns surrounding the issue of food security, this option is currently not pursued in South Africa.

2.11. Biodiesel from recycled used cooking oil

It is slowly becoming common knowledge that the world faces major depletion of petroleum fuel and increasing environmental challenges, such as climate change caused by high carbon emissions (Raghareutai, Chavalparit, & Ongwandee, 2010).

Literature reveals that recycling used cooking oil is an alternative source for biodiesel production as it is easily available from fast food outlets and other food premises, and is less complicated to produce biodiesel from used cooking oil (Ho, Wong, & Chang, 2014) and (Utlu, 2007).

Literature shows that the recycling of used cooking oil also addresses waste disposal challenges, especially if municipalities are proactive enough to regulate and impose stricter penalties for inappropriate handling of used cooking oil. This would help to keep used cooking oil away from municipal drainage systems. But a much better option is to channel this used cooking to recycling into biodiesel, as this will not only prevent the used cooking oil from re-entering the food chain, but to also help in job creation and reduction of carbon emissions (Ho, Wong, & Chang, 2014).

This review demonstrated how use cooking oil can be most effective. South Africa has very limited literature on the recycling of used cooking oil to produce biodiesel, hence the importance of this research in helping the country to pursue this option since using fresh cooking oil may have a negative impact on food security.

2.12. Environmental health and waste management

The greatest concerns regarding the issue of sustainable development and green economy has been the sustainable management of environmental wastes. This section focuses on the impact of proper waste management, regulations, disposal, and control of used cooking oil in the environment.

Countries such as Japan and the USA, have made huge progress in recycling used cooking oil for biodiesel production, and are more advanced in the treatment and implementation of environmental waste management policies that deal specifically with disposal of used cooking oil.

Zhang *et al,* (2014) argues that, to encourage biodiesel production from used cooking oil, countries must implement strict fines and penalties for illegal disposal of used cooking oil and must come up with policies and regulations for recycling used cooking oil; for example, these regulations may be used to force fast food outlets to pay garbage disposal fees (Zhang H. , Ozturk, Wang, & Zhao, 2014).

In China, the disposal of used cooking oil has been standardised for collection, transportation and disposal by municipalities; and some related sector departments have rules and regulations to manage of used cooking oil (Zhang, Wang , & Mortimer, 2012).

South Africa for instance, is currently developing a carbon tax policy with the aim of regulating carbon emissions. However, the regulation of used cooking oil seems to be lacking in most local municipalities (Nhamo, 2014).

Scholars, argue that government is key and plays a major role in promoting production of renewable fuel to ensure environmental sustainability through biodiesel production from recycled used cooking oil.

2.13. Economic impact

The limitation on biodiesel production has been high production costs as compared to petroleum diesel. Utlu, (2007), argues that the cost benefits of biodiesel production are usually gained through incentives, due to the fact that biodiesel production from used cooking oil has better investment returns and in most cases, production loss may be covered by further processing of glycerol (Utlu, 2007).

An economic sustainable biodiesel production is usually boosted by incentives or subsidies which tend to increase investment and encourage local production (Sims , Hastings , Schlamadinger, Taylor, & Smith, 2006); but this is an interesting area that other researchers may seek to explore extensively. Furthermore, the market and demand forces are also regarded as factors that are most likely to increase the cost of biodiesel (Utlu, 2007).

The costs of producing biodiesel from used cooking oil depends on the methods used in production. El-Gendy & Deriase (2015), argues that methods used in recycling used cooking oil for biodiesel production consumes large amount of water and the consequent waste treatment affect the reaction yields, and this usually impact on the costs of the whole manufacturing process (El-Gendy & Deriase, 2015).

It is unclear from literature how the impact on recycling used cooking oil to produce biodiesel may have on job creation, but due to the fact that

manufacturing is involved, it appears this sector may have the potential to create more local jobs, especially if there are proper policies and regulations in the sector (Borel-Saladin & Turok, 2013).

2.14. Agro processing

Huwee Ho, (2014), argues that biodiesel production has three market segments which are: suppliers, processors and end users, but indicated that government policies and regulations are key to biodiesel production and usage in these market segments (Ho, Wong, & Chang, 2014).

However, Huwee Ho, (2014); and Zhang, (2014), presents a supporting argument that agro processing requires support systems, such as incentives in the entire value chain and involves key stakeholders such as government (which plays the role of regulator & policy maker); biodiesel enterprises (as producers); restaurants (as waste oils producers); and collectors of used cooking oils from restaurants. (Zhang H. , Ozturk, Wang, & Zhao, 2014).

There are ideally two by-products from biodiesel production, identified as glycerol and soap. These two by-products are of great importance in the cosmetic industry as well as other high-value applications (Brandãoa, Penedob , & Pintoc, 2013).

In South Africa biodiesel is also produced as a by-product from soy-meal manufacturing, and this is currently happening in the Coega Industrial Park in the Eastern Cape. (Gustavo, 2010). Expanding agro processing industries is very much important as a job creation strategy. Although this is still pretty much in a small scale, it is promising, due to perceived future impact on job creation in agro-processing value chains.

2.15. Challenges facing small scale biodiesel producers

Most small scale biodiesel producers, are faced with challenges such as policy uncertainty, lack of incentives, and lack of market coordination. These policy

challenges may hamper small business development in the biodiesel industry (Gunatilake, 2011). However, some policies for biodiesel like those in India requires biodiesel producers to supply local and domestic public transport and government vehicles, this implies a focused policy to reduce carbon emissions.

In Thailand, the production of biodiesel from used cooking oil is still at a very small scale, constituting about 4 per cent of the country's total biodiesel production; and this may be attributed to shortage of technical skills, and political instability which threatens future investment; but there is potential for small scale recyclers as there is significant government support for biodiesel production (Eisentraut, 2010).

As a means of encouraging the practice of recycling used cooking oil, there is greater need for government to create public awareness, and provide enabling policies and regulations that will attract investment in the biodiesel industry (Gunatilake, 2011).

Gunatilake (2011), point out that some governments impose "administered prices", which in most cases are fixed prices for biodiesel. These administered prices are usually intended to encourage demand for biodiesel, but this policy may not be feasible and is unsustainable as increased production costs may drive profits down, especially in the absence of financial incentives for small biodiesel producers; and this may consequently crowd out foreign investments (Gunatilake, 2011).

2.16. Lessons from other countries

There are many lessons that could be learned from other countries producing biodiesel from used cooking oil. The United States is regarded as the world leader in biodiesel production (Zhang H. , Ozturk, Wang, & Zhao, 2014).

The USA and Japan have good policies to manage and recycle used cooking oil for biodiesel production. The USA has strict regulation and legislations to

deal with waste management and pollution; there are subsidies to encourage production and use of biodiesel; and heavy fines are issued to violators of regulations (Zhang, Wang , & Mortimer, 2012).

Similarly, Japan has enacted the food waste recycling law, which makes recycling an obligation for catering companies as a means of reducing waste generation; and also provides subsidies and tax incentives to encourage recycling of used cooking oil (Zhang, Wang , & Mortimer, 2012).

China is still struggling to manage the huge quantities of used cooking oil. While Singapore has shown potential for biodiesel from used cooking oil, it lacks marketing for biodiesel due to unawareness and very fewer biodiesel stations. Just like China, Singapore still lacks policies and regulations to manage biodiesel (Ho, Wong, & Chang, 2014).

2.17. Key successes of recycling used cooking oil to produce biodiesel

The success of countries like the USA, Japan and China in recycling used cooking oil to produce biodiesel have been influenced mainly by the role government plays through policies, waste disposal regulations, and collection fees (Zhang H. , Ozturk, Wang, & Zhao, 2014).

Japan has successfully reduced the reuse of used cooking oil for consumption in the catering industry through the adoption of a hygiene licence system, and strict daily supervision and risk management systems (Zhang, Wang , & Mortimer, 2012).

Apart from the subsidies and incentives offered to manufactures, the USA has put in place an infrastructure network for recycling used cooking oil to encourage the participation of transportation enterprises, and other stakeholders involved in biodiesel production (Zhang H. , Ozturk, Zhou, Yueming, & Wu, 2015).

Nhamo, (2014); and Borel- Saladin and Turok, (2013) point out that, government plays a key role in ensuring that the objectives of green economy are achieved; and indicating that these objectives may be achieved through policy support and industry regulation frameworks that encourages investment in green economy projects (Nhamo, 2014).

2.18. Concluding literature review

Discussions on green economy and production of biodiesel fuel have taken centre stage in recent years. This literature has revealed a number of challenges facing biodiesel producers; and also outlined numerous opportunities that support the importance of reducing greenhouse gases and carbon footprint. Various academics agree to a certain extent that recycling cooking oil to produce biodiesel plays an important role in achieving green economy objectives.

Biodiesel from vegetable oil has been demonstrated as a more attractive fuel to supplement petroleum diesel in South Africa. What is learned from this literature is that biodiesel has various feedstocks, the fact is that, it all depends on government policies as enabling factors in the utilisation of certain feedstocks as opposed to the others. Sunflower and soybean are the most suitable crops for biodiesel production in South Africa; but due to government policy against the use of fresh vegetables for any form of fuel production; then the use of used cooking oil is another effective and viable way of producing a sustainable biodiesel fuel (Amiguna & Musango, 2011).

This review concludes that recycling used cooking oil to produce biodiesel is the best option for South Africa. Therefore, for South Africa to succeed, it is best to learn from the successes and failures of other countries like the USA; Brazil, Japan; China; India, Thailand, and Singapore that have experience on both challenges and good polies to manage the production of biodiesel from recycling used cooking oil.

Other issues of providing support will remain in the hands of government to make available a sustainable market supported by good regulatory frameworks that will ensure collectors and suppliers of used cooking oils and agro processors achieve the green economy objectives of job creation and poverty reduction.

This literature also reveal that with good policies countries are able to reduce challenges facing the recycling of used cooking oil to biodiesel; and develop viable business ventures that can contribute to job creation, reduce social inequality; and that contribute to reduction in carbon emissions.

2.18.1. Main findings from Literature

The section on literature review has highlighted various themes driving this study. The theme on sustainable development is considered a broader concept providing the basis for global management of the environment to ensure sustainability of both current and future generations.

Green economy points to the need to achieve sustainability through economic activities related to distribution; production; and consumption of goods and services which will result in improved community livelihood over the long term, while reducing environmental risks and resource scarcities to future generations.

To achieve green economy there is a need for greater government intervention in creating a conducive environment for private investment, the need for national, provincial, and local government policies, incentives, and regulations synergies to promote investment in green economy projects. Ideally small investors will need to overcome their challenges of lack of financial support, and be able to stand on their own in the long run in order to achieve full unemployment, poverty alleviation; and reduced social inequality.

Literature pertaining to issues of recycling used cooking oil to produce biodiesel as a means of achieving green economy, proves that recycling cooking oil to produce biodiesel has reached an advanced stage in Western, European and Asian countries; and that lack of extensive literature on recycling used cooking oil in South Africa is an indication that this process is still undervalued or ignored in key policy discussions.

It can be argued that the recycling of used cooking oil to produce biodiesel has the potential to provide opportunities and future economic and environmental benefits; and hence the achievement of green economy objectives of job creation, poverty eradication, and social equity.

The recycling of used cooking oil has direct link to environmental management, economic impact, and agro processing, but the important stakeholder to facilitate biodiesel value chain is government through conceptualisation and implementation of green economy policies. Therefore lack of government intervention through policies and regulatory frameworks may discourage local and foreign investment in the biodiesel industry.

The production of Biodiesel is widely recognised as key economic activity as it has the potential to crowd-in further downstream production of other valuable by-products such as glycerine, and animal feeds, allowing further profits to be made in the long run. Many scholars predicts and confirms that the current resources for production of petroleum diesel are slowly depleting, thereby arguing in favour of production of renewable products in a sustainable way that does not impact on food security.

The recycling of used cooking oil is a well-supported option given the political view of not planting crops for the purpose of producing fuel, due to food security challenges in South Africa. The recycling of used cooking oil to produce biodiesel is said to have the potential to also solve challenges posed by illegal

dumping of used cooking oil in the sewage drainage, and environmental and public health risks when re-entering the food chain through illegal means.

The possibility of downstream value adding presents great potential for beneficiation of by-products, such as glycerol which is said to be useful in the cosmetic industry as well as other high-value chain products that may provide further investment and contribute to job creation, and more climate change resilient industries.

Chapter 3. Methodology

3.1. Methodology

This research used the following methodology to obtain information: the research paradigm; research design and approach; sampling strategy and criteria; data collection and analysis methods; validity and reliability; limitations; and ethical issues.

3.2. Research paradigm

A paradigm represent the way people think, act and do things in the world out there, but such actions cannot happen without reference to those paradigms (Wagner, Kawulich, & Garner, 2012). In this research on the challenges of recycling of used cooking for biodiesel production, the research paradigm was located in a qualitative research method as opposed to quantitative research method.

The qualitative research method was employed in order for the researcher to understand the social context which has shaped a variety of activities and patterns that are linked to issues around the theory of green economy as identified in the literature, these includes issues of job creation; reduction of greenhouse gas emissions; and uncovering knowledge about how people; businesses; and government view the environmental risks; sustainability; climate change; and economic challenges that affect South Africa ‘s green economy sector (Bryman, 2012).

The quantitative research approach was not fully employed in this research as it emphasises quantification in the collection of data and that it entails a deductive approach between theory and research, and usually strives to prove theories to allow explanations of certain predetermined laws or theories. (Bryman, 2012).

In order to get information on the quantity of used cooking oil that is available for recycling to produce biodiesel in Polokwane, some elements of quantitative data was collected to determine the amount of used cooking oil produced by food outlets. In order to calculate the costs and feasibility of recycling used cooking oil, seven food premises in Polokwane were asked about the amount of cooking oil they discard per month. However it should be noted that this was not a mixed method type of research.

3.3. Research Design

A Research Design is “a structure that guides the execution of a research method and the analysis of the subsequent data” (Bryman, 2012, p. 46). This research was aimed at finding out the economic benefits of recycling used cooking oil to produce biodiesel; the impact of reducing carbon emissions on job creation; the current status of provincial policies that regulate and support full scale production of biodiesel; and the environmental benefits of using biodiesel.

This research was undertaken within the interpretive qualitative research method due to the need to capture required information in an interactive way with participants. The use of interpretive qualitative method was to provide satisfactorily information that deals with required aspects of the research and for the researcher to closely assess respondents’ views on the challenges of recycling used cooking oil to produce biodiesel in Polokwane (Wagner, Kawulich, & Garner, 2012).

In addition the interpretive qualitative research provided the researcher with the ability to continuously do the analysis of data during the data collection process, and to do the interpretation and meaning making of the nonverbal symbolism and communication behaviour during the data collection process. By using this method, the researcher was able to clarify the questions and to checks with the respondents for accuracy of interpretation; and explore infrequent responses in

relation to the respondents' knowledge of the challenges and opportunities that are presented by producing biodiesel from used cooking oil.

The semi-structured interview technique method was used as a data gathering tool to allow the respondents to answer the questions as per list of questions and for the researcher to make follow-up on answers provided by the respondents' in order to get as much information as possible (Wagner, Kawulich, & Garner, 2012).

The interviews as a tool of gathering information was used to make meaning of the research data that was gathered through face to face interviews. As indicated above the semi-structured interview was consisted of open-ended questions; this type of interview has enabled the researcher to collect more information from respondents (Wagner, Kawulich, & Garner, 2012).

Furthermore the semi structured interview allowed the researcher to further probe the respondents based on what the researcher picked from the responses, and to get more information through follow up questions in addition to the structured questions for the interview; this approach enabled the researcher to link the responses to the research questions (Bryman, 2012).

3.4. Sampling strategy and criteria

As the design of this research was in the qualitative approach, the research was mainly on the non- probability purposive sampling strategy. The use of the non- probability purposive sampling was to achieve representativeness of the study and that the respondents were recruited based on their relevance to the research topic, and their ability to provide expected information needed to respond to the research questions.

The researcher personally approached respondents as per sample frame and has included seven food outlets which was consisted of four fast food outlets, one lodge, one hospital, and one hotel. This type of food premises were pre

identified as main producers of used cooking oil. The listed producers were viewed to have links with collectors or recyclers of used cooking oil from their premises.

The researcher also approached the Department of Economic Development, Environment and Tourism (LEDET) and the Polokwane Local Municipality officials to ask questions about government policies, economic activities related to recycling of used cooking oil, and environmental issues regarding management of used cooking oil. Therefore the choice of a non-probability purposive sampling allowed the researcher to choose the relevant respondents to respond to the research questions (Bryman, 2012).

The unit of analysis revolved around the policy makers (government institutions), sector regulators, businesses, farmers, households and transport deliveries. The unit of analysis was consisted of the following: at the Limpopo Department of Environmental Affairs and Tourism (LEDET); the Polokwane local municipality (waste management division); Biodiesel producers; collectors or delivery companies; fast food outlets/restaurants; hospitals; hotels and guests houses; and a few local farmers.

The sample focused on respondents in Polokwane and was consisted of 13 respondents: one senior official dealing with green economy in the Provincial Department of Environmental Affairs and Tourism; one senior official in the Polokwane local municipality dealing with environmental management; two small delivery transport companies (used cooking oil collectors and producers); four fast food outlets/restaurants; one hospital; one hotel; one guests house; two local farmers (biodiesel users).

The respondents were asked about their views and opinions, and their knowledge about economic opportunities of recycling used cooking oil; biodiesel; greenhouse gas emissions; climate change; and job opportunities or employment in the biodiesel sector.

The fact that this research has used qualitative approach; has allowed a more robust understanding of the problem under investigation. The literature review revealed certain themes and knowledge gaps in this research on the challenges in recycling used cooking oil to produce biodiesel, and has guided this research such that the method used allows for a new theory to emerge from the interviews with the selected respondents The subsequent sections will deal with the data collection; data analysis tools used; and the recommendations made in this research.

3.5. Data collection methods

This section outlines the data collection method used and the reasons for using the particular method.

3.5.1. Primary data

The researcher was the primary collector of data, and the data collection technique employed was conducted through face to face semi-structured interviews in order to enable the researcher to obtain information on the views and opinions of respondents (Neuman, 2006). The table bellows shows the various sources of data.

Table 1: Table of data sources

Data Sources
• Four fast food outlets • One Lodge • One hotel in Polokwane • One hospital in Polokwane • Two biodiesel users • One biodiesel producer (recycler) • One senior official from LEDET • One Senior Official from Polokwane Municipality

The actual research in the field work revealed that biodiesel producers actually performs the duty of collectors of used cooking oil and there is no “middle man”

collecting the used cooking oil on their behalf. The original sample that was presented in the research proposal had two small delivery companies as collectors of used cooking oil. When going to the field it was later realised that the biodiesel producer (the used cooking oil recycler) does the collection of used cooking oil from fast food outlets, hotels, and guest houses (lodges).

The initial sampling of small delivery transport was based on the researcher‘s assumption that small delivery transport companies would maximise data representation in the recycling of used cooking oil (Bryman, 2012). In Polokwane City there were no small delivery transport companies identified in the used cooking oil value chain, since the recycler of used cooking oil collects the oil from fast food outlets.

Therefore the small delivery transport companies was withdrawn from the sample as the recyclers of used cooking oil was found to be the one doing both collection and recycling (producing biodiesel using used cooking oil). The biodiesel producer is considered to be at the core of the research data.

The participation of all respondents was voluntary and the purpose of the research was properly explained to all participating respondents. The respondents were given assurance that their identity will not be revealed without their consent. The researcher continued to maintain high level of confidentiality and all participants will remain anonymous (Wagner, Kawulich, & Garner, 2012).

All interviews were conducted on an individual basis, and questions were structured to suite the social and economic roles that the respondents play in the field of green economy, environmental health and waste; and the recycling industry with particular focus of recycling used cooking oil (see questionnaires in appendix 2). Data from the officials of the LEDET and the Polokwane municipality was attained by means of in depth one-on-one semi-structured interviews with questions based on the role they play in facilitating, planning

and implementation of green economy policies; and environmental health and waste management services; and the questions that were asked to fast food outlets and users of biodiesel were on the amount of used cooking oil discarded; amount of biodiesel used; and knowledge of biodiesel benefits, business and socio economic issues.

The technique or method used to collect data was as follows: interviews of less than 30 minutes were conducted per individual respondent, and were consisted of between 1 - 14 open ended questions excluding the follow-up questions.

The interview responses were transcribed into a note book, and some were recorded with the consent of the interviewee and an explanation was provided at the beginning of each interview that the reasons for recording interview proceedings was to enable the researcher to get more information and not miss any information that the respondent would provide. The interviews for those that refused to be recorded was recorded only as notes for the interview. (Wagner, Kawulich, & Garner, 2012).

The collected data and recorded information was transcribed for compilation of the research report. The researcher has tried by all means to avoid biasness and to report responses in a favourable way (Creswell, 2014).

The data collection programme was structured in a way that will give the researcher enough time to collect data and also do data analysis as ideas for analysing collected data were emerging during the interviews. The researcher used recording device to ensure and tracking of analytical insights (Patton, 2002).

Data analysis was conducted simultaneously with data collection to make it easier for the researcher to keep focus of the interviews, and to enable the researcher to observe any theories coming from the interviews; and this made it easier for the researcher to start to make sense of information gathered;

coding to understand themes and theories coming out from the data and make it easy to compare information from different respondents as a means of developing good theory from the findings of the research (Creswell, 2013).

Data analysis was done to interpret information that was obtained from respondents to get an overview of the respondent's experiences and knowledge relevant to this research; including the challenges and benefits of recycling used cooking oil to produce biodiesel (Creswell, 2013). In addition, the research also found out from respondents about their knowledge of the objectives of green economy and the reduction of greenhouse gas emissions.

3.5.2. Secondary data

Secondary data was also used and included annual reports, annual strategic planning and Polokwane local municipality documents published on the website such as local economic development plan; waste management plan; and integrated development plan. The secondary data information was used for cross reference purpose and to get other valuable information that the researcher felt was omitted by the Municipality officials during the interview.

It is estimated that South Africans uses approximately 1.2 million tons of vegetable seeds oil annually. Table 2 below shows the actual and estimated annual consumption of soybean oil, sunflower oil, palm oil and other vegetable oils in South Africa. Economic growth was regarded as the main driver for the increase in the demand for oil extracted from various oilseed (Esterhuizen & Pickelsimer, 2015).

Table 2: Consumption oil seeds (soybean oil, sunflower oil, and palm oil) in South Africa

Marketing year	2013/14 (actual)	2014/15 (estimate)	2015/16 (forecast)
Sunflower oil	410	350	350
Soybean oil	230	270	300
Palm oil	430	460	460
Other oils	80	100	100
TOTAL	**1 150**	**1 180**	**1 210**

Source: Global Agricultural information network

Currently there is no reliable data on the amount of used cooking oil in Polokwane and in South Africa at large, but according to Sithole, et al, (2014, p1133), “The amount of waste cooking oil available in South Africa on a monthly basis is in excess of 30 million litres” (Sithole, Jalama, & Meijboom , 2014). Therefore in this research data will be collected to get a sense of the amount of used cooking oil that can be available for recycling in Polokwane.

3.6. Validity and Reliability

This qualitative research has used the interview technique, and as such the process may not be as stable as one wishes it to be over a period of time; therefore at some point the information collected from government and municipality respondents may have some elements of biasness; therefore some of the information was cross checked for consistency using relevant documents such as annual reports and IDPs to be assured that the findings of the study be as reliable as possible (Wagner, Kawulich, & Garner, 2012).

According to Wagner et al, (2012, p80), “ensuring the validity and reliability of the measure used for the data collection phase of your research helps to ensure the overall quality of the research process and end product” (Wagner, Kawulich, & Garner, 2012).

To ensure reliability some of the quotes from the respondents were taken as they are for use as evidence that the respondents has responded to the questions asked by the researcher. During the interviews some of the questions needed be clarified to ensure the respondent understands what was required by the question (Bryman, 2012).

The data triangulation, was done to examine data evidence from various respondents to improve validity of the gathered data. Data especially for users

of biodiesel and producers of used cooking oil (because their questions were similar per category) required comparisons to evaluate the degree with which their responses could be closer to the initial responses if the interview was to be conducted to the same respondent again, but given the distance to Polokwane and time constrains, this proved to be impossible to achieve (Wagner, Kawulich, & Garner, 2012).

3.7. Limitations

The limitations in this study was suspicion that one of the respondents in the fast food outlets withheld information in respect of the company that collects used cooking oil from the premises; the LEDET respondent was undermining the researcher and may have provided distorted responses due to personal bias, politics, and was emotional when responding to other interview questions. (Patton, 2002). In addition, another limitation was on the side of the Municipality where the researcher was referred to a junior employee, but this was understandable since the senior official was on leave and the junior was an experienced staff member and works directly with the issue under investigation (Wagner, Kawulich, & Garner, 2012).

One of the most limitation on the side of the researcher was the issue of distance due to the location were the research was based, but this did not impact on the researcher‘s ability to successfully complete the study as the researcher managed to complete the research within the specified time frame.

3.8. Ethics

Although there was no sensitive information in this research, the researcher was always on the guard for ethical issues and had avoided ethical violation (Creswell, 2013).

The researcher had clearly communicated the methodology, and the purpose of the research (Wagner, 2012: 63). The following ethical considerations were

observed to avoid ethical infringements: Informed consent and level of confidentiality.

3.8.1. Informed consent

Each interview session began by requesting consent and explanation regarding the purpose of the research. The researcher had informed consent form, but none was used as respondents' preferred verbal consent (Wagner, Kawulich, & Garner, 2012).

3.8.2. Level of confidentiality

The researcher maintained confidentiality, and ensured respondents that the information provided will only be used for the research purpose (Wagner, Kawulich, & Garner, 2012). The respondents to this research will remain anonymous and have been coded to hide their identity. The interview transcripts have been clearly marked as confidential.

Chapter 4. Data presentation

4.1. Introduction

This chapter will present the data collected on the research on the challenges in recycling used cooking oil to produce biodiesel in Polokwane. The data was collected using semi-structured interview technique conducted with respondents identified using non-probability purposive sampling method.

4.2. Data presentation process

This section outlines the data collection process followed in this research. The data presentation process entailed the transcribing of information from notes and the recordings from a recording device. The process also involved the coding of respondents (to ensure anonymity), paraphrasing and properly organising the information to give meaning to raw data, and also maintain the flow of ideas.

Raw data from field work was categorised into 4 sections identified in order to classify various respondents and themes in the study. The first section consists of data collected from producers of used cooking oil which includes the following units of analysis as per sample strategy: four fast-food outlets, one lodge, one hotel and a hospital.

The second sections deals with data collected from a biodiesel producer (recycler of used cooking to produce biodiesel); the third section deals with policies and regulations and it includes two respondents, one from the Polokwane Municipality and another one from LEDET; the fourth section involves two users of Biodiesel (motorists not farmers as was initially indicated in the sample); There is a change from the initial sample as the “collectors” small delivery vehicles were removed from the sample since the recycler does the collections of used cooking oil from fast food outlet. These change helped the researcher to keep the discussions focused on the main themes of the research

4.2.1. Producers of used cooking oil

This section is represented by seven respondents from four fast food outlets; a guest house (lodge); a hotel; and a hospital.

Data was collected by conducting one on one interviews with respondents. A questionnaire consisted of eleven (11) open ended questions was developed and was structured in a way that enable the researcher to get as much information as possible from respondents, in order to answer the research questions.

The Interview questions ranged from the type of cooking oil used by food outlets; the number of deep fryers fast food outlets have in the business; the amount of cooking oil they dispose on a daily, weekly or monthly basis; what they do with the used cooking; whether there is anyone collecting used cooking oil from their premises; the frequency of having the used cooking oil removed; who collects used cooking oil from the food premises; the cost of having used cooking oil removed; whether there is any contractual agreement to have the used cooking oil removed; and what the respondents know about recycling (questionnaire attached as appendix 2).

The four fast food outlets interviewed were coded as fast food outlet 1; fast food outlet 2; fast food outlet 3; fast food outlet 4; and the other food premises do not require coding and will be the Lodge; the Hotel and the Hospital.

The following are the results from the interviews with respondents. Subheadings were used to easily identify and differentiate data presented.

Type of used cooking oil used

With regard to the type of cooking oil used, majority of fast food outlets indicated they used sunflower and palm cooking oil. Sunflower oil is believed to be the

most consumed cooking oil in South Africa, followed by Palm oil (see table 2 above. Secondary data section).

Number of deep fryers and amount of used cooking oil produced

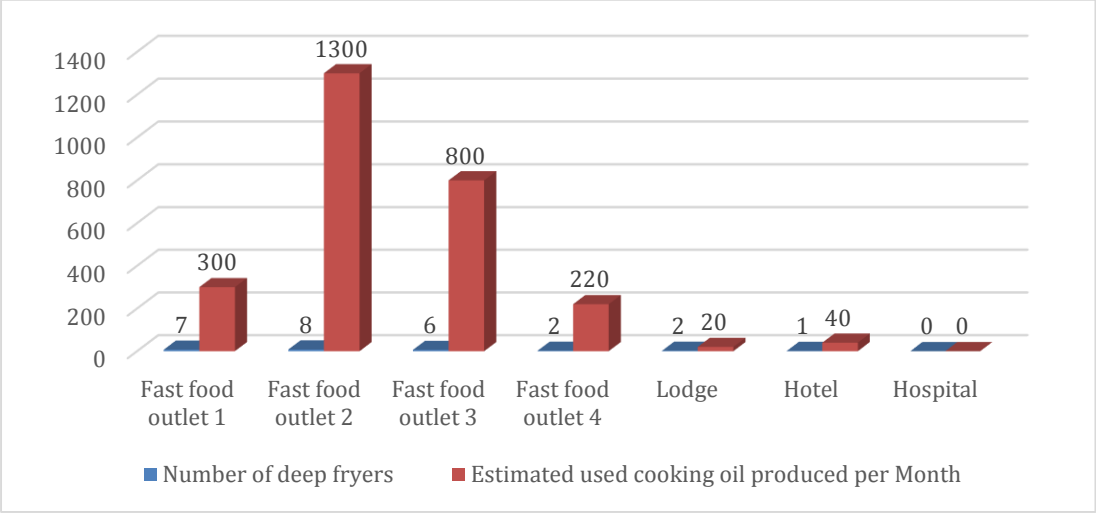
The number of deep fryers that a respective fast food outlets have are varying, and in most cases correlates with the amount of used cooking oil produced by a respective food outlet. The food outlet that has many deep fryers tend to produce a lot of used cooking oil per month.

Table 3: Estimated used cooking oil produced per month

Food outlet	Number of deep fryers	Estimated used cooking oil produced per Month
Fast food outlet 1	7	300
Fast food outlet 2	8	1300
Fast food outlet 3	6	800
Fast food outlet 4	2	220
Lodge	2	20
Hotel	1	40
Hospital	0	0

Source: Own creation using data collected from food outlets in Polokwane (2016)

Figure 2: Deep fryers versus used cooking oil produced per month



Source: Own creation using data collected from food outlets in Polokwane (2016)

Table 3 and figure 2, above shows the amount of used cooking oil produced by the researched food outlets in Polokwane, and also depicts the number of deep fryers in relation to the used cooking oil produced. The amount of oil produced also varies based on the type of the food outlets

Fast food outlet 1, has seven deep fryers; and produces 10 litres per day (estimate of 300 litres per month); the food outlet has separate deep fryers for chips and chicken.

Fast food outlet 2, has eight deep fryers (five for chicken and three for chips); and produces about 325 litres per week [about 1300 litres per month (325 litres x 4 weeks)]; but this also depends on the demand as more oil can be discarded when the demand for food is high.

Fast food outlet 3, has six deep fryers (four for chicken and two for chips; and produces about 400 litres in two weeks (estimated 800 litres per months). This may depend on the condition of the oil; if the oil is still usable after two week they continue using the oil. This does not give us a clear view of monthly quantity of used cooking oil produced.

Fast food outlet 4 has two deep fryers; and produces about 40 to 60 litres per week (average of 55 litres per week (55 litres x 4 weeks gives us an estimate of 220 litres per months)

The lodge has two deep fryers; and produces 20 litres per month; and he hotel has one deep fryer and produces 40 litres per month.

Hospital has no deep fryer as they use grillers as opposed to deep fryers. Hospitals normally do not produce used cooking oil, and the little they produce from their grillers is washed away with water when they clean the dishes.
The food outlets that specialises in deep fried food (fast food outlets) are there ones producing large quantities; when combined they produce an estimated 2

620 litres of used cooking oil compared to only 60 litres produced by the food outlets dealing in accommodation (the lodge and the hotel) but provides food for guest.

Disposal and collection

The changing or disposal of used cooking oil depend to a larger extent on the condition or quality of the used oil after several use. Both respondents indicated that *"if the oil is too dark (quality of the oil) it means the oil is no longer good for use"* (interviews, 24 January 2016).

The data collected shows that the majority of fast food outlets are selling and making their used cooking oil available to collectors (recyclers) of used cooking oil in Polokwane; although there are a few outlets that are selling the used cooking oil to their customers.

Table 4: Type of disposal and amount received for the used cooking oil

Food outlets	Deep fryers	Estimated UCO produced per Month	Price (R) per 20 litre container	Type of disposal
Fast food outlet 1	7	300	120	Sell to customers (public)
Fast food outlet 2	8	1300	unknown	collection
Fast food outlet 3	6	800	70	collection
Fast food outlet 4	2	160	70	collection
Lodge	2	20	70	Return to supplier for discount
Hotel	1	40	60	collection
Hospital	0	0	0	not applicable

Source: Own creation using data collected from food outlets in Polokwane (2016)

Fast food outlet 1 sells the used cooking oil to their customers *"we sell to customers"*. Whereas Fast food outlet 2, 3, 4 and the hotel sells their used cooking oil to a collector (recycler) of used cooking oil.

The lodge returns their used cooking oil to the supplier of fresh cooking oil for a discount when they buy fresh cooking oil. The lodge indicated that before they became aware that they can get a discount on the used cooking they use to keep the oil in the premises not knowing what to do with the oil and sometimes use to give the oil to staff members. *"We use to keep the oil in the premises and sometimes use to give out the oil to staff members*" (interview, 23 February 2016).

The Hospital normally does not produce use cooking oil. The respondent sighted health reasons due to the fact that the food is prepared for patients and that cooking oil would pose health risks to patients.

Frequency of collection

Fast food outlet 2 has someone who collects the used cooking oil two times per month, but this also depends on business, because in December they can collect three times. This fast food outlet say it has a big drums where they store the used cooking oil, and they call the collectors when these drums are full.

Fast food outlet 3 has a collector and the used cooking oil is collected every 2 weeks; and fast food outlet 4, also has a collector and is a company

The lodge does not have anyone collecting. *"We return the used cooking oil when we go to buy new cooking oil, usually once per month"*.

The hotel "*there is a company that collects we call them when the container we use to keep the oil is full, usually return the oil once a month"*.

Hospital "we do not use cooking oil" not applicable.

Agreement to have used cooking oil removed and knowledge about recycling of used cooking oil.

Table 5 below shows information about the existence of agreements to have the used cooking oil removed from the food premises and knowledge about recycling by respondents

Table 5: Agreement for collection and knowledge about recycling

Food outlets	Agreement to have used cooking oil removed	Knowledge about recycling of used cooking oil
Fast food outlet 1	No collector	No idea about recycling
Fast food outlet 2	Respondent does not know, since contract are handled by head office	used cooking oil used to make shoe polish, and candles
Fast food outlet 3	No signed contract between the fast food outlet and the collector	Respondent knows that the used cooking oil is used to make paint, diesel, soap, medicines for animals. Information from head office of the outlet
Fast food outlet 4	"No agreement, it's a first come first serve" anybody can collect the oil from the outlet	Not much only knows that the used cooking oil is used to make fertilisers and biofuels but does not know about the process
Lodge	No collector	No knowledge , but suspect that the oil is turned back into usable cooking oil
Hotel	Verbal agreement	To make biofuel. Respondent got the information obtained from the collector
Hospital	Not applicable	Does not know

With regard to agreements the above table 5 shows that food premises are not bound to fulfil any contractual obligation to provide the used cooking oil to the collector (recycler), meaning that the market for used cooking oil is still open to any collector. This is a challenge for the existing collector as it implies that there is no security of supply to the collector (recycler).

4.2.2. Policies and regulations

The rationale behind this category of sampling is to get information from the government regarding support for initiatives aimed at promoting green economy goals and objectives. This section has two respondents, namely Respondent 1 (Polokwane local municipality); and Respondent 2 (from LEDET).

4.2.2.1. Polokwane Municipality

The Polokwane municipality was included in the sample in order to get an overview on the policies and regulations related to the issue of monitoring and control of used cooking oil, and that of production of biodiesel; including the ways in which used cooking oil is disposed. This was also informed by the fact that government usually provides support to small producers in an attempt to encourage investments.

The following are the results from the discussions with Respondent 1 from the municipality.

Municipality's involvement in green economy

Respondent 1, indicated that the issue of green economy is about trying to do things in a way that is compatible or sustainable for future use and not just think about the environment for the benefit of today, but also for the benefit of future generation,

"As much as green economy is concerned, is a concept that is used to achieve things in order to make sure that we achieve sustainability".

Respondent 1, indicated that Polokwane is not a heavily industrialised area, but one of the most contributors to air pollution in the area is vehicle emissions especially in the CBD. The municipality has projects like the Bus Rapid transit (BRT) system whereby most commuters will have a specific mode of transport which is more environmentally friendly and can carry more passengers, which is also more time efficient and encourage people to use public transport as opposed private vehicles in order to achieve green economy status.

As far as the BRT is concerned, Respondent 1, says that the BRT is a project that is aimed at reducing carbon foot prints.

"*We also do air pollution monitoring in the city to see what the environment is receiving at the moment, also receive monitoring reports from major*

contributors to the air pollution so that the municipality can see what they are doing so that they can make recommendation to them".

It is important to note that the municipality has initiatives aimed at achieving green economy and sustainability. The challenge is that the municipality is planning the BRT to reduce carbon foot print through reduction of vehicles on the roads. It is not clear whether BRT will still use petroleum fuel or biodiesel.

Green economy plans and strategies in the municipality

Respondent 1 indicates that the municipality has policies in place, but these policies resided with the transportation and environmental strategic business unit*. "The municipality has air quality management plan which is addressing how the municipality plan to manage the air quality in the city".*

Monitoring and control of used cooking oil

Respondent 1, indicated that the regulation and monitoring of used cooking oil in food premises by the municipality is done to ensure health and food safety; and to prevent the oil from entering the municipality's drainage systems.

The monitoring and inspections of food premises also encourages food premises to sell their cooking oil instead of flushing used oil in drainage systems and selling to customers. The used cooking oil sold to customers is allegedly ending up in the domestic kitchens of the poor households who cannot afford fresh cooking oil. The fact that used cooking producers have collectors of used cooking that buy the oil serves as an incentive to encourage recycling.

Dealing with used cooking oil in food premises

Respondent 1, indicated the municipality have a register of all food outlet and ensures that this food premises have links with the collectors of used cooking oil. Frequent inspections are conducted to monitor the accumulation of used cooking oil in the food premises in order to ensure that the used cooking oil is disposed in a legal way or through a collector. Of importance to note is that it is not compulsory for food premises to sell the oil to a specific recycler, but they are not allowed to flush the oil through municipality's drainage systems.

The municipality has about 191 food premises that are monitored for compliance with food safety regulations which includes the monitoring of used cooking oil. The municipality hasn't as yet developed a proper register that records the amount of cooking oil disposed by food outlet; but it seems there is a good relationship between the food premises and the municipality regarding the disposal of used cooking oil.

Policy compliance enforcement

As part of the monitoring and control system the municipality's environmental health inspection may issue a fine to a food outlet for noncompliance with proper disposal of used cooking oil. Currently this is considered as a control measure in terms of food safety regulation which regulates the over using of cooking oil by food outlets. The inspections also involves monitoring that the used cooking oil is not flushed through the municipal drainage systems.

"We don't really have a direct policy or by law towards the used cooking oil at the moment. Food outlets cooperate with advises from the food inspectors that the oil is no longer good for use and they also see that the oil is no longer fit for use, and at some outlets the inspectors don't even need to go there time and again to say that the oil is no longer fit for use as over use of cooking oil will

also affect the quality of their food, so it is also the outlet's responsibility to dispose the used oil. They dispose the oil into the empty bucket" (interview, 23 February 2016).

The inspections of food premises are done in terms of Regulation 962 of the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act no. 54 of 1972), which also governs amongst others the over using of cooking oil by food premises as part of the food safety regulations.

"*We don't only check the oil, we check everything about food safety, from the food that is in the premises to how the food is stored, and if the food is still sound, we don't only check the used cooking oil, unless there is suspected illicit activity connected to reusing or over using of cooking oil, then the inspector can do that specifically (checking of used cooking oil). Over using of cooking oil forms part of food safety regulations"* (interview, 23 February 2016).

Measures to control used cooking oil

The municipality does not have a policy or a by law to deal directly with the improper handling or disposal of used cooking oil, meaning that they depend on the Regulation 962 of the Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act no. 54 of 1972).

"But food outlets won't sell (used cooking oil) openly, but may do this as an underground type of agreement; the inspector knows that there is a specific group of people who prefers using that oil; they buy it as it is and use it for other things, and inspectors my not immediately be aware or know because the perpetrators knows they are not supposed to sell the oil, but just put it as part of the oil that is going to be collected by the recyclers, whereas they know that they are going to sell some of it again. Inspections of food premises are done

in terms of the law there is regulation 962 of the food stuff, cosmetics and disinfectants act, so when we do our regulations (monitoring)"

Policy guiding local biodiesel production and regulation

There is uncertainty with regard to policies regulating local production of biodiesel. The respondent was not so sure that the used cooking oil which is collected from the food premises is for production of biodiesel instead they think the oil is temporarily stored, and then transported elsewhere.

Respondent 1 did not have knowledge that biodiesel production from used cooking oil is happening in the city; but only knows that the used oil is collected from the food outlets by a certain company.

Here the challenge is that the municipality does not do follow up with the collector to see what the collector is doing with the used cooking oil. This suggest that there is need for a policy to regulate collectors to monitor how the used cooking is treated post collection from food premises; this will also help to prevent the chances of used cooking oil from being sold to poor communities.

Challenges in dealing with used cooking oil

Respondent 1, indicate that there is no specific challenge because the inspectors advise food outlets to dispose the over-used cooking oil, in terms of the law and that the oil is declared unfit for human consumption by a devise (equipment) they use to measure the quality of cooking oil.

"The only concerning thing we experience is when people cheat, when you ask them to dispose then do so, but later they use it again, then that you can never know, but when people are honest then it is easily done. Oil is expensive and an example is another food outlets which use to fry chips in old oil and store

the chips as fried and when you order they reheat the chips in the new oil. But there are no major cases of refusing to dispose, but sometimes people may argue that the oil is still fit for use, in such instances you tell them that the devise (equipment) cannot lie".

Knowledge about biodiesel

Respondent 1, seems to have basic knowledge and defined Biodiesel as an alternative fuel from petroleum diesel, saying that biodiesel is reportedly much cleaner than the normal petroleum diesel.

"*We will get reduced emissions when we are using this type of oil. The important thing is when we get reduced emissions because vehicles are the biggest contributors of emissions".*

Air pollution control (air quality management plan)

The municipality also has an air quality management plan, which deals with monitoring of air pollution by companies and vehicles (mostly diesel vehicles) as they are considered the highest carbon emitters. Diesel vehicles are regarded as the highest polluters in the city of Polokwane and Respondent 1 has acknowledged that biodiesel would help reduce the pollution in the city. The challenge is that there is no formal awareness to encourage motorist to use low carbon emitting fuel like biodiesel.

"With the vehicles we monitor mostly the diesel vehicles when they are emitting a lot of dark smoke, because obviously the dark smoke is due to incomplete combustion, so if there is that smoke emitted from the exhaust we already know that there is something wrong with the vehicle, then those vehicles are sent to the testing station and given a period to fix the vehicle within a specified period and there is a fine attached in terms of the municipality traffic by-law. Because

we do air pollution we work with the traffic; we use hartridge meters to measure the smoke emissions from the exhaust depending on the capacity of the car (engine capacity). Vehicles are the most polluters" (interview, 23 February 2016)

Job creation

With regard to whether there are any jobs being created in recycling of used cooking oil to produce biodiesel in Polokwane, Respondent 1, was not so sure, but assumed that the recyclers are creating jobs in the recycling plant.

4.2.2.2. Provincial green economy policies and regulations

The section was included in the sample in order to get an overview of the Limpopo provincial policies and regulations related to green economy and the support to recyclers of used cooking oil to produce biodiesel. This was also informed by the fact that producers would be expected to meet certain legislative requirements to operate in biodiesel productions and for the Provincial Department to provide policy and financial resources to promote investment in projects that aims to reduce emissions and climate change through support for recycling to produce Biodiesel.

In terms of the constitution, 1996 environmental activities are a concurrent function mandated to the National, Provincial and Local government spheres of government. Therefore at a provincial level LEDET has the responsibility of providing policy direction and implementation of the green economy goals.

However the interviews conducted with Respondent 2 from the LEDET revealed that the office of the premier coordinates the green economy implementation for the entire province (coordination of green economy inputs from various provincial departments).

According to Respondent 2, the Limpopo green economy plan is not geared towards reduction of carbon emissions, but the focus for the province is on the response to climate change caused by carbon emissions of other developed countries. Respondent 2 further indicated that, there are no obligatory sectors of green economy in the province, for example there are sectors which are convenient for circumstances in terms of the renewable energy.

Respondent 2, indicates that the purpose of green economy is to reduce emissions, and that in the process of reducing carbon emissions there should be benefits through increased economic growth, and should do so through practices that do not destroy natural environment; that do not cause more pollution, and that don't need more natural resources.

Respondent 2, has shown no knowledge of projects that are recycling used cooking to produce biodiesel in Polokwane, but instead indicated that if such a project exist they might think they are producing green biodiesel whereas they are not; indicating that the recycling of used cooking to produce biodiesel can be done in the wrong way, but would encourage recycling if it is done correctly.

"If recyclers have to collect used cooking oil then the whole chain has to be green; so you can produce the so called green products in a non-green way which at the end its not serving the purpose". (Interview, 09 march 2016)

Respondent 2 indicates that the aim of the department was to provide strategic direction regarding the green economy, and the office of the premier coordinates everything that happens in the province. The Respondent further indicate that the issue of reducing carbon emission is the responsibility of the local municipality as it is their mandate to implement pollution and waste management problems.

Respondent 2, indicates that the green economy achievements so far is with is the plan itself, because it has concrete focus areas and the province is in the process of implementing the plans which are coordinated by the Limpopo Office of the Premier. The green economy plan implementation process is said to be right on time to meet the set targets as there are structures in the province that coordinates the implementation of various focus arears.

According to the respondent, the province requires political by-in in terms of implementing green economy plans, for example there is a need to encourage mineral resources to be extracted in a sustainable way. There is a lot of pollution caused by mining companies and most mines are not encouraged to use renewable energy.

The information on creation of employment through recycling of used cooking to produce biodiesel is sketchy, since both respondents 1 and 2 from the municipality and the provincial department are not so sure about what is happening with the used cooking oil that is collected from food premises. However this information cannot be generalised for the whole municipality as the respondents may not be best place to know such information.

Although the Limpopo provincial green economy has targeted 86 000 jobs in all its focus areas it is not clear as to how much is targeted in production of renewable fuels such as biodiesel. A Polokwane biodiesel production company has so far created six jobs opportunities in a project that is seen as contributing to green economy.

4.2.3. Recycler of used cooking oil to produce Biodiesel

The rationale behind this section of the sample was to identify the impact recyclers have in the whole value chain of recycling of used cooking oil, and how this would contribute to responding to the overall research questions of the study, particularly with regard to economic benefits of recycling used cooking

oil; the impact on green economy and job creation; and how this then links to the overall theory on green economy.

Furthermore, this section is directly linked to the research topic. It should also be noted that recyclers forms part of the unit of analysis. In this research the recycler is also the collector of used cooking oil from food premises, therefore the researcher deemed it necessary to combine recyclers and collectors of used cooking oil, and thereby removing collectors or delivery companies from the sample, hence reducing the overall sample to 12 respondents.

While the researcher was proceeding with the actual research, it became clear that recyclers themselves are the ones who go out to the food outlets to collect used cooking oil. Since this research is utilising the purposive sampling method, there was no need to interview any small delivery transport companies who are not involved in collecting used cooking oil.

The findings of the data collected from the recycler are evident to what has been discussed above, and below is the summary of the interview with the manager of the recycling company. The manager of the business was interviewed and has been coded as respondent 3 for the purpose of this research.

Respondent 3 indicated the recycling of used cooking oil to produce biodiesel is economically sustainable, because the used cooking oil is cheaper to obtain and is bought from fast food outlets at a price of R3.00 per litre and that it would have been expensive to produce biodiesel using fresh cooking oil.

According to Respondent 3, the arrangement to obtain used cooking oil is a mutual relationship, but in this case the recycler enjoys preferential advantage to get the oil, because this recycler also sells fresh cooking oil to fast food outlets, and in return buys back the used cooking oil from the same fast food outlets at an agreed price of R3.00 per litre or R70.00 per 20 litre container.

This arrangement benefits both the recycler and the food premises (mostly fast food outlets), simply due to the fact that when the recycler get used cooking oil for recycling, the food outlets gain extra money out of oil which was regarded as waste and could have been easily thrown away without gaining anything.

Respondent 3 indicated that the main sources of used cooking oil are restaurants (fast food outlets), and all other big supermarkets (big retail stores that have fast food component), lodges, and hotels. The respondent indicated that they have delivery vehicles that collects the used cooking from food premises.

According to Respondent 3, the main challenge is that the business uses homemade customised machines, and this is a challenge to the recycler as the machines are slow in production. In essence what this tells us is that if this machines are slow the possibility is that there could be more used cooking oil accumulating in their storage without being used as fast food outlets are supplying used cooking oil on a monthly basis.

Another challenge is infrastructure provision for production facility as Respondent 3 indicates that the production facility is small and is used for all the company's production needs since all activities are housed in the same building (the office, the filling station, and production processes are done in the same building). Currently their production is said to be sitting at 2 000 litres per day, and is able to meet their current market demand.
"The business needs new machines that produce faster. The facility space is also small and is used for everything, the office, the filling station, and productions are in the same building" (interview, 23 February 2016).

Respondent 3 indicated that the sector's skills needs in production of biodiesel requires a laboratory technicians (for doing the test and actual production of biodiesel); an assistant technician (responsible for removing residues from the

used cooking oil); delivery drivers and their assistants for collection of used cooking oil from fast food outlets and for delivery of biodiesel to customers.

"Restaurants (food premises) uses palm oil for cooking meat and when you are cooking meat there will be small pieces of meat that will be left in the cooking oil and when they discard the oil they just mix all the oils in the same container. When the oil comes here (to the recycler) the assistant technician will filter the used cooking oil to remove the small pieces of meat before we can use the cooking oil for production of biodiesel"

The current technician is not a professionally qualified biodiesel production technician as he was only trained on the job. This may be because the recycling facility may not be so complicated to warrant a professionally qualified technician or that the sector may not be so attractive to qualified professionals due to the fact that it is still in a small scale.

Respondent 3 indicated that the byproducts from biodiesel production process are sold to a soap manufacturing company in Polokwane. This provides the potential for further by products processing which might have an impact on job creation

The market is still very small as the target market are private cars, farmers, delivery trucks in surrounding industrial areas.

The Respondent 3, indicated that their biodiesel is produced in three forms, namely: B50 (50 % biodiesel blended with 50 % petroleum diesel); B100 (80% biodiesel blended with 20 % petroleum diesel); and B100 (100% biodiesel). These blends are in line with blending as recommended by the Department of Energy in terms of regulation 671 of the Petroleum Products Act, 1977 (Act No 120 of 1977), which allows for the minimum concentration to blending allowable for biodiesel to be 5 percent (Department of Energy, 2013).

Table 6: Specifications, standards and pricing of biodiesel produced in Polokwane

Biodiesel	Pricing	Petroleum Diesel	Pricing
Biodiesel 50 (B50) 50 % biodiesel plus 50% petroleum diesel	R9.60 per litre*	50ppm	R11.25 per litre*
Biodiesel 100 (B100) 80 % biodiesel plus 20% petroleum diesel	R9.24 per litre*	10ppm	R11.22 per litre*
Biodiesel 100 (B100) 100 % biodiesel	R9.24 per litre*	500ppm	R11.06

* March 2016 prices

Source: own creation using data collected from the biodiesel producer in Polokwane and prices of petroleum diesel as at march 2016.

Table 6 above shows specifications of the produced biodiesel and the respective prices.

Respondent 3 indicated that most heavy vehicles (delivery trucks) drivers prefers to use B100 (100 percent biodiesel) because they say it last longer, and is also cheaper. As shown in table 6 above the price of B100 is R9.24 per litre is less compared to petroleum diesel 500ppm which costs R11.25 per litre (a saving of R2.01 per litre can be a big gain for motorists when using B100 compared to 500ppm)

Although the sector has various forms of financial support systems such as the green fund which was set up to encourage investment in renewables, there are still other prospective producers that still struggles to access such funds. Respondents 3, indicated that there is no support from government so far. "*There is no support coming from government; but different government officials have visited this business and promised to fund the business next year (2016/17)*" (Interview, 23 February 2016).

But it seems the business gets support from other family businesses that produces sunflower oil, where the recycler gets sunflower cooking oil at a reasonable price. This also add as a positive factor for sustainability of the business as a whole not only the recycling component.

4.2.4. Biodiesel end- users or motorists

In this section the aim was to find out the views of the users with regards to the use of biodiesel such as why they use biodiesel, accessibility to biodiesel filling points; and to establish if there are any benefits gained in using biodiesel.

In this section two respondents were interviewed: Respondent A and Respondent B. The interview results are as follows:

It seems the knowledge about availability of Biodiesel is still new in Polokwane, as both Respondent A and B indicates that they have known about biodiesel last year in October (2015)

Respondent A: "*I have known about biodiesel last year October (2015)"*

Lower carbon emissions

Respondent A has indicated that biodiesel is different from other diesel fuel, because of the smoke which is not harmful to the human health; and only uses the filling station that is at a biodiesel producer premises in Polokwane.

Access to biodiesel filling station

Respondent A, buys biodiesel at Biodiesel Company located in the industrial area in Polokwane. For this respondent accessibility of the filling station might not be a problem as the filling station is located closer to his place of work (this respondent delivers goods to some store warehouses that are located closer to the biodiesel filling station). Respondent B also does not have problems with accessing the biodiesel filling station.

Respondents' thought about biodiesel

Both Respondent A and B thinks biodiesel is good for the vehicles and indicated there has been no change in the condition of the engine ever since they started using biodiesel. Both say they do not see any difference between biodiesel and

petroleum diesel with regard to performance; and both also indicated that biodiesel lasts longer than the petroleum diesel. Respondent B: *"people must use it does not damage cars*".

Demand, supply and price affordability

For both the Respondent A and B, the main reasons for using biodiesel is because it is cheaper than petroleum diesel fuels and perceives it to last longer than petroleum diesel.

Respondent A indicated that *"with a biodiesel for R900.00 he can travel from Polokwane to Thohoyandou and back to Polokwane {this is a distance of approximately 388 kilometers (km)], and still use the same biodiesel to go to a place like Mokopane town and back again (a distance of about 116km) before filling the tank again (the total distance is approximately 504 km travelled with a R900.00 worth of biodiesel)".* According to Respondent A, for a distance of 504 kilometers he will have to top up the fuel when using petroleum diesel

But Respondent B indicated that the only reason for using biodiesel is that *"it is a cheaper diesel and that's all, if other diesel were cheaper than biodiesel he was not going to use biodiesel"*. Respondent B, continued to say he likes diesel cars because diesel fuel generally last longer than petrol (interview, 09 March 2016).

This means that biodiesel users, value the price affordability more than the need to reduce carbon emission, or that they do not know about the impact of biodiesel on emission.

The researcher was able to identify only one supplier of biodiesel in Polokwane, and is located in the industrial area of Polokwane. The challenge is that this

producer seems be far from exposure to most motorists who might be interested in using biodiesel, due to the location of the business.

4.3. Summary of findings

The above presented data has revealed to a certain extent the challenges in recycling of used cooking oil in Polokwane. The finding identified are discussed below:

With regard to the availability of used cooking oil for recycling into biodiesel, Polokwane seems to have sufficient used cooking to support a sustainable used cooking oil recycling business.

Although a number of food outlets have indicated they are selling their used cooking oil to a recycling company a few of them still sells to their customers or the public. The challenge is that selling of used cooking oil for other activities compromises the chances of recycling the used cooking oil for biodiesel production.

In most cases formal contractual agreements may help recyclers to secure a sustainable supply for used cooking oil, which may lead to stable production Therefore the challenge for the existing recycler (Respondent 3), is that full accessibility to the used cooking oil is not guaranteed in the long term, as a fast food outlet may decide at any time to sell the used cooking oil to any other new recycler who may offer a better price for the used cooking oil.

Generally the respondents are only interested in getting rid of the used cooking oil by selling to the collectors/recyclers as they do not have formal agreements to have the oil removed; and does not know much about the recycling of used cooking oil. This lack of formal agreement may imply that the used cooking oil in Polokwane is still freely available to any business interested in recycling used cooking oil.

It appears that the municipality does not have a clear policy and regulation regarding the disposal of used cooking oil by food outlets. However municipal environmental health inspectors offers advice for food outlets to change the cooking oil when it is no longer fit for use, but cannot force them to sell to a recycler due to lack of policy.

The basis for changing or disposal of used cooking oil is that, if cooking oil is over used it affect the food safety and health of consumers. This provides an opportunity for recycles to get the used cooking oil since food outlets are not allowed to dispose the oil through selling to customers or flushing in municipal drainage.

Municipality conducts inspections and monitor the accumulation used cooking oil in the food premises to ensure the used cooking oil is disposed in a legal way. Therefore, nowadays with the emergent of recycling used cooking oil the environmental health inspectors' are now advising the food premises to sell the used cooking oil to recyclers, as selling to customers also have other health ramifications.

It was maintained that as part of the environmental health inspections, each inspector has a register of all food outlet within his/her jurisdiction and ensures that the food premises has links with the collector of used cooking oil in order to be able to control the disposal of such oils.

The challenge is that it is not compulsory for food premises to sell the oil to a specific recycler, due to the fact that the law that is used to compel them to change the used cooking oil does not specify that the used cooking oil must be collected by a recycler. Food outlets sell their used cooking oil to recyclers because they do not have other options of disposal since they are not allowed to flush the oil through municipality's drainage systems or sell to customers.

As part of the municipality ‘s monitoring and control system the municipality’ s food premises inspector may issue a fine for noncompliance with advises from the inspector that the oil has reached the end of its useful term

Given all sorts of monitoring by the municipality there seems to be some illicit activities taking advantage of lack of regulations to force them to dispose the oil. So far it remains the prerogative of the food outlets to make sure that the oil is removed from the premises or sold to the recycler. This is a challenge as it reduces the chances of the recycler to claim full access to the used cooking oil discarded by various food outlets

Given that recyclers are paying for the used cooking oil collected, fast food outlets are becoming more attracted to selling to recyclers than selling to staff members and the public through illicit way.

The municipality has the responsibility for air quality management, which deals with monitoring air pollution by companies and vehicles in the city. The fact that there is a pollution plan gives the city better leverage to create awareness to encourage investors to considers investing in recycling of used cooking oil to produce biodiesel and to also encourage motorist to use less carbon intensive fuels like biodiesel.

It was indicated by Respondent 1 that Polokwane municipality has a planned BRT system. This initiative has the potential to encourage further investment in recycling used cooking oil to produce biodiesel production if the BRT system was planned to use biodiesel fuel as effective tool to reduce air pollution, than to focus on mainly on reducing traffic congestions in the city.

It would appear that there is uncertainty with regard to policies regulating local production of biodiesel. The municipality is not so sure that the used cooking

oil which is collected from the food premises is for production of biodiesel instead they think the oil is temporarily stored, and then transported elsewhere for recycling

The information on creation of employment through recycling of used cooking to produce biodiesel is sketchy. The respondents 1 and 2, did not have enough knowledge about jobs that are created in the recycling of used cooking oil. They also lacked knowledge that biodiesel production from used cooking oil is happening in Polokwane; but at least they know that the used cooking oil is collected from the fast food outlets by a certain company. However this information cannot be generalised for the whole municipality as the respondents may not be best place to know such information.

The findings reveal that that the office of the premier coordinates the green economy implementation for the entire province (coordination of green economy inputs from various provincial departments). It was indicated that that the Limpopo green economy plan is not geared towards reduction of carbon emissions, but the focus for the province is on the response to climate change caused by carbon emissions of other developed countries.

The purpose of green economy is to reduce emissions, and that in the process benefiting through increased economic growth through practices that do not destroy natural environment; that do not cause more pollution, and that don't need more natural resources.

The province has structures in place tasked with the implementation of the green economy. In Limpopo the office of the premier coordinates green economy inputs from other sector departments in the province.

The recycling of used cooking to produce biodiesel can be done in the wrong way, *If recyclers have to collect used cooking oil for recycling into biodiesel,*

then the whole chain process has to be green; so you can produce the so called green products in a non-green way which at the end its not serving the purpose". (Interview, 09 march 2016)

The respondent indicates that the aim of the department was to provide strategic direction regarding the green economy, and the office of the premier coordinates everything that happens in the province.

There seems to be no green economy achievements with regard to recycling of used cooking oil projects supported; the respondent indicates that the plan itself is an achievement because it has concrete focus areas and the province is in the process of implementing the plans which are coordinated by the Limpopo Office of the Premier. The respondent further indicated that the green economy plan implementation process is right on time to meet the set targets as there are structures in the province that coordinates policy implementation.

According to the respondent, the province requires political by-in in terms of implementing green economy plans, for example there is a need to encourage mineral resources to be extracted in a sustainable way. There is a lot of pollution caused by mining companies and most mines are not encouraged to use renewable energy.

The information on creation of employment through recycling of used cooking to produce biodiesel is sketchy, since both respondents from the municipality and the Limpopo provincial department are not so sure about what is happening with the used cooking oil that is collected from food premises. However this information cannot be generalised for the whole municipality as the respondents may not be best place to know such information.

Findings from the interviews with the respondent 3 (recycler) shows that the recycling of used cooking oil is both economically sound and sustainable,

because the used cooking oil is cheaper to obtain and is bought from fast food outlets at lower prices and that it would have been expensive had they been using new cooking oil.

Lack of contractual obligations to collect the used cooking oil from the food outlet may compromise the security of supply and sustainability of the recycling business. However the existing recycler seems to be enjoying preferential advantage to get the oil, as there is no other known recycler around (still no competition, but watch the space).

Furthermore the fact that the recycler also sells fresh cooking oil to fast food outlets, and in return buys back the used cooking oil from the same fast food outlets at an agreed price of R3.00 per litre or R70.00 per 20 litre container, seems to be working as a strategy to ensure continued supply.

There is a challenge in terms infrastructure provision for production facility as the recycler‘s facility is small and is used for all the company’s production requirement since all activities are housed in the same building (the office, the filling station, and production processes are done in the same building).

Currently the byproducts of biodiesel production are sold to a soap manufacturing company in Polokwane, this may increases the chances of investment in downstream processing of glycerol. There is a gap with regard to the support provided by government since the recycler has indicated that there is no support current offered by government.

Consumers seems to be more interested more on the affordability than the need to reduce carbon emissions. The market is still very small as the target market are private cars, farmers, delivery trucks in surrounding industrial areas. Biodiesel does not seem to have any negative effect on the condition of the engine. The interviewed users, Respondents A and B have indicated that they

do not see any difference between biodiesel and petroleum diesel with regard to performance. Both indicates it tend to last longer than the normal diesel.

The location of the biodiesel producer may be playing against the recycler as it is located in the industrial area of Polokwane. The challenge is that it may not be exposed to other motorist who might be interested in using biodiesel due to its proximity.

Chapter 5. Analysis

5.1. Introduction

This chapter will deal with the analysis of qualitative primary data gathered using qualitative interviewing method. The data was coded by giving respondents names that are only for the purpose this study and to protect their identities. The themes identified in this study were interpreted and analysed to get to the core of the research problem.

This chapter specifically entails the analysis of data to uncover the challenges in recycling used cooking oil to produce biodiesel in Polokwane. The analysis is based on the fact that qualitative data analysis seeks to develop theory from interviewees' responses (Bryman, 2012).

5.2. Data analysis process

The process entailed the discussion of various themes identified in the data presentation process, and includes the following themes: Used cooking oil availability; Turning waste into valuable resources for biodiesel production; demand for biodiesel in Polokwane; skills development; job creation; investment opportunities; downstream value chain; and Bus Rapid Transit.

The data presented in chapter 4 above revealed to a certain extent, some of the challenges in recycling used cooking to produce biodiesel in Polokwane. The findings also prove that recycling of used cooking oil may unlock job opportunities in Polokwane. However there are varying challenges such as poor implementation of government policies to support small scale recycling of used cooking oil to produce biodiesel. The research findings identified are analysed and discussed in detail below:

5.2.1. Used cooking oil availability (resource availability)

The data collected on the amount of cooking oil discarded by food outlets proves that there is high potential for a well-structured market for used cooking oil; and this presents opportunities for recycling used cooking oil to produce biodiesel in Polokwane.

The data collected shows that fast food outlets have the potential to produce on average 640 litres of used cooking oil per month; and that hotels produces about 40 litres; and lodges produces about 20 litres per month.,

To calculate the estimated amount of used cooking oil available in Polokwane per month, a list of all registered food premises was sourced from the Polokwane municipality. The list revealed that there are approximately 191 fast food outlets; 4 hotels; and about 56 Lodges and guesthouses (only those that cook food for guests were included).

Table 7: Estimated litres of used cooking oil available in Polokwane and revenue projections

Food outlets in Polokwane	Number of food outlets	Litres of used cooking oil produced by each outlet per month (estimate)	litres of used cooking oil produced per month	Price (R') per litre of used cooking oil	Revenue generated (estimate)
Fast food outlets	191	640	122,240	3	366,720
Hotels	4	40	160	3	480
Lodges (cook food for guests)	56	20	1,120	3	3,360
TOTAL	**251**	**700**	**123,520**	3	370,560

Source: Own creation using information obtained from Polokwane Municipality (2016)

As shown in the table 7 above it can be seen that Polokwane‘s food premises have the potential to produce an estimated 123 520 litres of used cooking oil per month; and are able to generate an estimated revenue of R366 720 per month. Notwithstanding the fact that fast food outlet 1 sells the used cooking oil to its customers, there is still plenty of used cooking oil available for recycling. In this instance it is the duty of the Polokwane local government to encourage

small businesses to venture into recycling of used cooking oil as a means of creating job opportunities for the communities, through enabling policies.

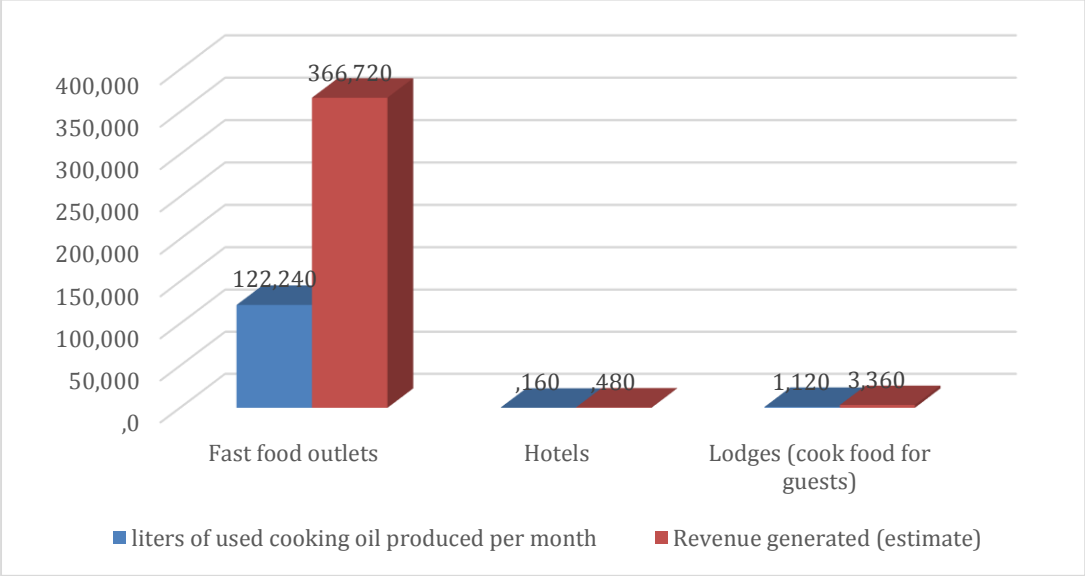


Figure 3: Quantity of used cooking oil and revenue generated

Figure 3 above and figure 4 below shows that, fast food outlets are the highest contributors of used cooking oil, accounting for about 122 240 or 98 percent of total estimated used cooking oil production in Polokwane, mainly due to the fact that they specialise in deep frying of food; followed by lodges at 2 percent.

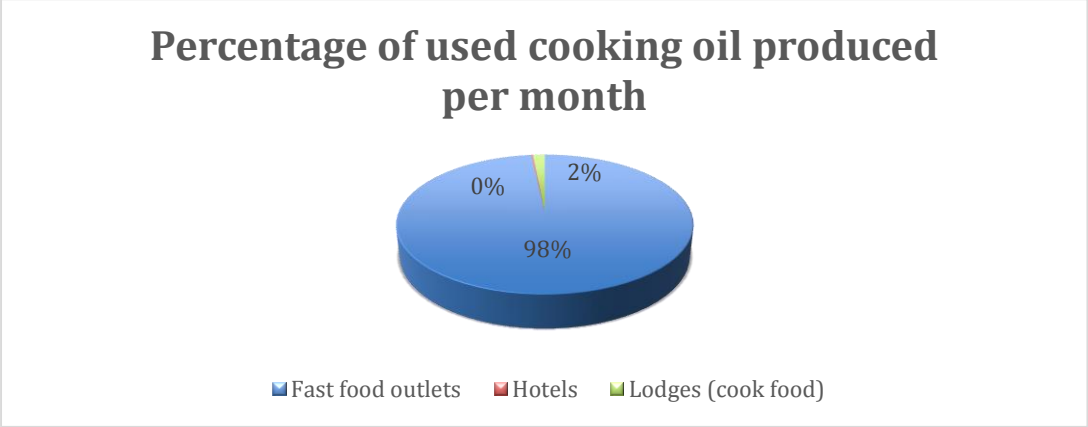


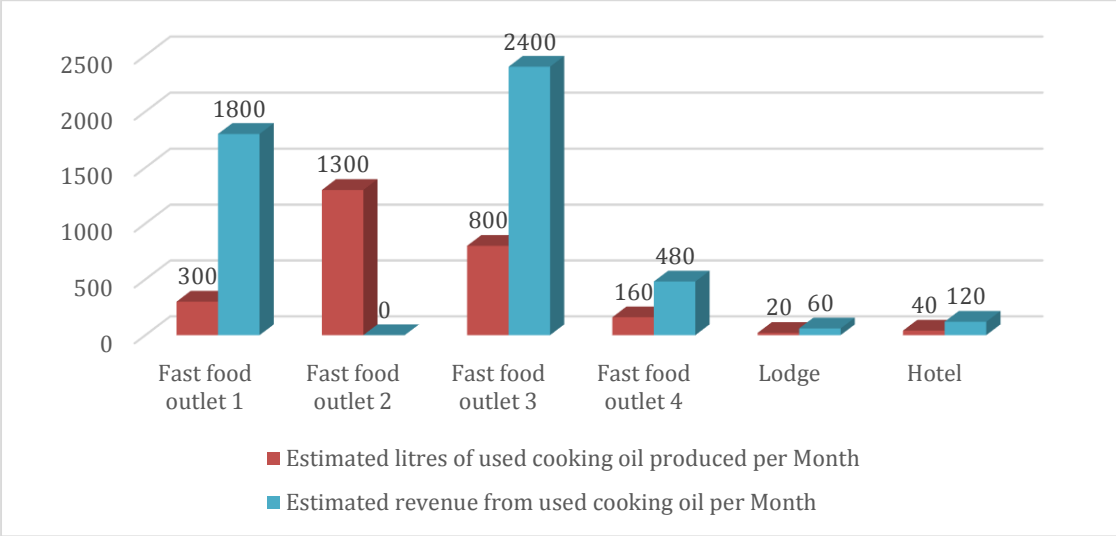
Figure 4: Percentage of used cooking oil produced by food outlets in Polokwane

Source: own creation (2016)

Revenue generated by food outlets from sales of used cooking oil

There is potential for a sustainable supply of used cooking oil to recyclers, this is due to the fact that food outlets are selling their used cooking oil and not just giving away.

Figure 5: Revenue generated (in rands) from used cooking oil



Source: Own creation (2016)

Another important thing to note is that the revenue earnings from selling used cooking oil tend to motivate fast food outlets to sell to collectors or recyclers. As seen in figure 4 above, fast food outlet 3 is able to generate about R2 400 per month through selling the used cooking oil to a collector (recycler), this is extra revenue that will encourage the food outlet to continuously sell the used cooking to recyclers, thereby increasing their revenue earnings to boost their cash flow.

However fast food outlet 1 charges more for the used cooking oil than any other food outlets and sells the oil to customers for R120 per 20 litre bucket. This suggest that there are willing customers to buy the used cooking oil, especially in the absence of regulations that forces outlets to sell the oil to recyclers. Another reason may be that, fast food outlet 1 may not want to sell to the recycler due to the low price that the recycler is prepared to pay compared to

what their customers are able to pay. The recycler pays R70.00 per 20 litre bucket, which is far less than the R120.00 when selling to customers.

Table 9 shows that the food outlets that have a collector of used cooking oil sells their cooking oil in the same price, this suggest that this outlets might be price takers than price setters, as the revenue generated from sales of used cooking oil is far less than the one for fast food 1, that sell to its customers. This is an indication that there is a need for regulation of the recycling of used cooking oil, so that there can be uniformity on how the used cooking oil is disposed and sold to recyclers.

Table 8: Price and collection of used cooking oil

Food outlets	Number of deep fryers per food outlet	Estimated litres of used cooking oil produced per Month	Price per 20 litre bucket	Recycler Price (R) per litre	Estimated revenue from used cooking oil per Month	Type of disposal
Fast food outlet 1	7	300	120	N/A	1800	Sell to customers
Fast food outlet 2	8	1300	unknown	unknown	unknown	collection
Fast food outlet 3	6	800	70	3	2400	collection
Fast food outlet 4	2	160	70	3	480	collection
Lodge	2	20	70	3	60	Sell to recycler
Hotel	1	40	60	3	120	collection

Source: Own creation

Surely the way in which the collection and disposal is currently done shows that there is lack of regulation. Fast food 4 even mentioned that the collection of used cooking oil is a “first come first serve” meaning that any other person can buy the used cooking oil from fast food outlet 4 other than the regular collector/recycler.

Most fast food outlets are more concerned about making extra cash from selling used cooking oil than on reducing environmental waste in the drainage systems, or supporting biodiesel initiatives. Therefore this may suggests that the issue of reducing emission doesn’t matter much to them.

5.2.2. Turning waste into valuable resources for biodiesel production

It is clear from the information gathered, that used cooking oil is now moving away from the kitchen and drainage systems to becoming a valuable resource for the recycling industry as some of the food outlets are preferring to sell their used cooking oil to a biodiesel recycler as opposed to selling to the public/customers.

It was recognised that the municipality is more engaged on the part of monitoring the environmental health risks posed by used cooking oil and has a formal or meaningful engagement when it comes to ensuring the used cooking oil does not re-enter the food chain in any way or another; therefore the municipality‘s role then may benefit recycling businesses; meaning that recycling businesses may get access to resources for use in the production of biodiesel.

The recycling of used cooking oil depends on using resources that were regarded as harmful to human health and the environment into valuable biodiesel products; in this case the recycling of used cooking oil produces biodiesel, and at the same also produces useful by-products that could be converted into valuable products in soap making.

The environmental benefit is such that the food outlets are aware of the risk of flushing used cooking oil through municipality drainage system and the health risk this causes to human health if cooking oil is over used. Therefore, communities around Polokwane will no longer be exposed to environmental health risks, increasing the chances of living a healthy life.

It has become common knowledge that the used cooking oil poses significant challenges due to incorrect disposal methods previously used by fast food outlets, including the possible contamination of the sewage and water resources. The recycling of used cooking oil is an attempt intended for job creation, and reduction of carbon emissions as suggested by proponents of green economy and sustainable development.

5.2.3. Demand for Biodiesel in Polokwane

The use of biodiesel in mostly as a transport fuel (an alternative to petroleum diesel fuel). According to Respondent 3 (biodiesel producer) in Polokwane, Biodiesel is available in three distinct forms (standards) namely, B50 (50 % biodiesel and 50 % petroleum diesel); B100 (80% biodiesel & 20 % normal diesel); and B100 (100% biodiesel).

The demand for biodiesel varies according to price, quality or standards, and the usage preference by vehicles owners (mostly delivery trucks). The most used biodiesel was found to be B100 (100% biodiesel), with both respondents A and B saying B100 is cheaper and last longer compared to petroleum diesel and other Biodiesel blends.

Table 10 shows the prices of biodiesel compared to petroleum diesel fuels. As shown in table 10 below, biodiesel users are likely to save about R1.83 per litre if they substitute 50ppm with B50; and also likely to save about R1.82 per litre when using B100 instead of 500ppm (especially heavy vehicles). It can be assumed that the difference in prices between Biodiesel and Petroleum diesel is likely to motivate users to convert from using Petroleum diesel, and the resulting impact is reduced emission as increased biodiesel use is considered to lead to less carbon emissions than Petroleum diesel

Table 9: Comparison of Biodiesel price and Petroleum price in Polokwane

Biodiesel	Pricing (rands per litre)	Petroleum Diesel	Pricing (rands per litre)	Difference (rands)
Biodiesel 50 (B50) 50 % biodiesel plus 50% petroleum diesel	9.60*	50ppm low sulphur	11.43*	1.83
Biodiesel 100 (B100) 80 % biodiesel plus 20% petroleum diesel	9.24*	500ppm low sulphur	11.06*	1.82
Biodiesel 100 (B100) 100 % biodiesel	9.24*	500ppm low sulphur	11.06*	1.82

*Pricing for March 2016

Source: Own creation (2016)

The most important motivating factor for using biodiesel for Respondent A and B appears to be mainly affordability. This makes sense given the fact that users of biodiesel would be able to realise some savings during this harsh economic condition were most consumables are very expensive, particularly with the price instability in the fuel industry. The ever increasing petroleum diesel prices will also encourage more and more motorist to convert from petroleum diesel to biodiesel if the latter is promoted widely in the Polokwane local communities and made known as a cheap fuel which produces less carbon emissions.

There is one known biodiesel producer in Polokwane and the demand for biodiesel is based on the supply by this producer. The producer has indicated that they usually sell everything they produce and sometimes are forced to produce more than their normal production scale of 2000 litres per day, mainly due to high demand, but the machines that they currently used can go as far as 4000 litres per day. Respondent 3 has indicated that to operate at such a high rate, the production machine will have to operate day and night in order to reach the target of 4000 litres per day.

Table 10: Projected cost and revenue from recycling used cooking oil to produce Biodiesel

A	B	C	D	E	F	G
Recycling company	**Production capacity (litres) per month (estimate)**	**Price (rands) per litre of used cooking oil**	**Cost of used cooking (BxC)**	**Price of biodiesel (B100)**	**Revenue generated (rands) per month (estimate) [BxE]**	**Profit margin (rands) (estimate) [F-D]**
Respondent 3	40,000	3	120,000	9.24	369,600	249,600
TOTAL	**40,000**	**3**	**120,000**	**9.24**	**369,600**	249,600

As shown in table 11 above, Biodiesel is produced at a much smaller scale in Polokwane. Respondent 3 (biodiesel producer), produces an estimated 40 000 litres per month. The calculation is based on the assumption that production is equal to demand. From the production quantity of 40 000 litres, the producer has the potential to generate a projected revenue of R369 000

Users of biodiesel seems to be disappointed by the fact that they know only one filling station in Polokwane, and that biodiesel supply is limited in other parts of the province; and are forced by circumstances to use petroleum diesel when they are in other parts of the province. In this regard there is a need to create awareness and to promote biodiesel in the Polokwane municipality, for example by using it in municipal vehicles.

Eisentraut, (2010:164) confirms the scale of biodiesel production from recycled used cooking oil in South Africa; by indicating that "A small quantity of biodiesel is produced from recycled cooking oil" (Eisentraut, 2010). This research has also found that biodiesel is still new in Polokwane, and there are few users of biodiesel. There is a need by the municipality and the provincial government to promote and support investments aimed at recycling used cooking oil to produce biodiesel.

Many people may not be aware of the availability of biodiesel in Polokwane as there are no fuel stations in the city other than the one located at the production site which is in fact in a poor market isolated area. The station closes at 17h00 in the evening, meaning that there is no access to biodiesel users after the factory has closed.

5.2.4. Job creation

As more litres of used cooking oil are destined for recycling to produce biodiesel, recyclers in Polokwane now have an opportunity to source more used cooking oil for biodiesel production. This means that more workers would be required for more oil collections and for actual recycling processes. Respondent 3 currently employed six people in both collections and production process, suggest that the capacity to create more jobs is very minimal as a job driver in the Municipality, and will need a boost in the form of incentives such as jobs fund.

It is widely recognised that green economy aims to create jobs, reduce poverty and inequality for sustainable development; and Biodiesel as a sub sector of green economy must also contribute to job creation. The biodiesel value chain is labour intensive as it requires, collection drivers, Technicians (who runs laboratory test) and assistant technician (to filter used cooking oil).

Findings show that policies and regulations may influence increased supply of used cooking oil, which has an impact on the growth of biodiesel industry due to expected increase in recycling used cooking oil for biodiesel production. Therefore an increased production capacity would mean increased job opportunities for local communities; and this also provides advantages in respect of economies of scale.

But so far very few jobs have been created due to the size of the existing facilities and seemingly lack of enabling policies and government interventions such as provision of infrastructure and financial injection to stimulate investment and job opportunities in the sector.

Since there is already an indication of a few jobs created in the recycling of used cooking oil, it is evident from the findings that there are other processors who tend to benefit from the by-products of biodiesel and this will also contribute as a multiplier effect for jobs creation in the green economy sector. Respondent 3 indicated that the recycler currently sell by product to a soap manufacturing company.

The jobs in the fast food outlets are somehow not directly influencing the biodiesel production, due to the fact that, even if there is no biodiesel production, the used cooking oil will still be discarded by fast food outlets since fast food outlets do not solely exist for the purpose of producing used cooking oil for recycling. However it could be safe to say that the extra cash offers a healthy cash flow for food outlets such that the food outlet may even consider

appointing additional staff to specifically manage the disposal of used cooking oil destined for recycling into biodiesel.

Since Polokwane has an unemployment rate of about 32 percent; the six jobs already created in the recycling process may be considered very small with no impact in reducing the unemployment rate; but this jobs are valuable to the surrounding communities as they make a difference to the socio economic and livelihood of the families of the employed individuals.

5.2.5. Skills development

Usually small biodiesel producers faces the challenges of skills shortage, because of the technical skills required in biodiesel production. Skills shortage may limit development of biodiesel industry (Eisentraut, 2010).

The sector‘s skills needs in Polokwane point to the need for laboratory technicians; drivers of used cooking oil collection vehicles and for delivery of biodiesel to customers. In this regard, skills development will be required to capacitate the recycling sector with relevant skills in the recycling of used cooking oil. Respondent 3 has indicated that he is not a professionally qualified technician, as he was trained on the job. The challenge is that the sector may not be so attractive to most qualified professionals, due to the fact that it is still in a small scale and may not be rewarding properly.

5.2.6. Downstream value chain

There is also an indication that the biodiesel production is supporting downstream production with the sale of biodiesel by-products such as glycerol. As indicated in the interviews. Respondent 3 indicated that they sell by-products to soap producers.

Brandãoa, *et al* (2014), indicates that glycerol and soap are the two main by-products of biodiesel and that these by-products are of great importance in the

cosmetic industry as well as other high-value products (Brandãoa, Penedob , & Pintoc, 2013). In essence the overall processing of used cooking oil does not end with the production of Biodiesel, but continues further with the use of by-products that can be further converted into valuable products.

Therefore, the further processing of by products have a positive impact on job creation; what is required is good policy to unlock opportunities. As there is an indication of lack of good policies to support recycling of used cooking oil, the same could be true that further processing also does not get support from government.

5.2.7. Government support

It should be noted that one of the Limpopo green economy plan‘s short term goal is to create an enabling environment for municipal by-laws and provincial policies and legislation to be reassessed to support the green economy model (LEDET, 2013).

Looking from the angle of the support required on recycling of used cooking oil, is that there is a need to unlock investment potential of recycling used cooking oil, through links with various affected provincial departments. Respondent 2 indicated that implementing green economy requires all affected departments to work together, as there is no one obligatory sector to deal with green economy.

5.2.7.1. Policy regulations and support for recycling of used cooking oil

The most important tool that is envisaged in attracting and promoting recycling of used cooking oil in Polokwane is the regulation of used cooking oil and the development of a broader value-chain link, which is consisted of used cooking oil producers (food outlets); the recyclers of used cooking oil into biodiesel; and other relevant stakeholders in a well-coordinated manner that strives to achieve

the green economy objectives of job creation, poverty alleviation, and social equity. By doing so, it would be easier to identify all the role players and to recognise the extent of support required to promote the use of biodiesel and awareness with regard to reduction of emissions; and also as part of small business development.

Government plays an important role in regulations and support of various sectors; unlike the policies in the USA, Polokwane does not have strict laws that forces fast food outlets to sell the used cooking oil to a biodiesel producer; there is no enough policy support to a local recycler of used cooking oil.

Therefore, there is a need for a policy to regulate how the used cooking oil should be disposed; government regulation would be helpful in creating a well-established supply market for used cooking oil and to provide awareness to food outlets regarding the importance of recycling used cooking oil.

The policies adopted by cities in USA, include amongst others imposing penalties for not recycling cooking oil and to force restaurants that produce used cooking oil to pay garbage disposal fees (Zhang H. , Ozturk, Wang, & Zhao, 2014). This is not the case with Polokwane, as findings show that food outlets are given fines for over-using cooking oil, not on the way used cooking oil should be disposed; but the way the Polokwane municipality is currently doing it may also help in one way or the other.

5.2.8. Policy coordination

The Province has a green economy plan which seeks to strengthen the response to climate change adaptation for sustainability. In most cases the success of a policy is usually seen by its achievement. The fact that the province ‘s focus is on response to climate change than reducing emissions suggests that provincial policy focus could be impeding initiatives in recycling used cooking oil to produce biodiesel. Respondent 2 indicated that the province

is already vulnerable to climate change and the only thing that can be done now is to adapt to climate change.

The reduction of carbon emissions through the recycling of used cooking for biodiesel will depend to a certain extent on the appropriate specific interventions by government, since government is considered as a key stakeholder in green economy (Nhamo, 2014). However other stakeholders such as private sector and other non-government organisation should also be seen to be playing an active role in ensuring that the goals of green economy are realised for the benefit of society in general.

5.2.9. Investment opportunities

Despite the relatively small size of the biodiesel sector and its accompanying slow growth in Polokwane, several challenges have been identified as factors affecting the much needed investment for sustainable recycling of used cooking oil value chains. The key challenges in investment identified in this research is infrastructure, lack of direct policy and financial support to promote recycling of used cooking oil for biodiesel production.

Limpopo ‘s green economy plan is not geared towards reduction of carbon emissions, but focuses on the response to climate change caused by carbon emissions of other developed countries. If green economy plan is not geared favorably towards reductions of carbon emissions, then obviously government ‘s financial resources may not be directed to less priority projects, and this may discourage prospective businesses to invest in recycling used cooking oil to produce biodiesel in the medium to long term.

The findings suggests that new biodiesel production machines are expensive. The challenge is that this will make investment in this type of a business unattractive to prospective investors. In order to ensure future investment in recycling of used cooking oil, government would have to fast tract its support

for a local biodiesel production businesses to ensure the recycling of used cooking oil is sustainable as part of government initiatives geared to reduce carbon emissions and job creation.

5.2.10. Bus Rapid Transit (BRT)

The main challenge identified by the municipality has been carbon emissions from vehicles, and there is an indication for a Bus rapid transit (BRT) programme in the pipeline. The findings show the main aim of the BRT system is to encourage people to use public mode of transport as opposed to using private vehicles through the introduction of an efficient public transport which is more time efficient and to contribute to the reduction in carbon foot print and the achievement of green economy goals.

Since Polokwane is planning a BRT system, they will have to fuel the buses with biodiesel from recycled cooking oil. This will also provide good ground to put together regulations aimed at encouraging food premises to sell cooking oil to recyclers. Furthermore, this has the benefit to keep the transport cost down and encourage car owners to consider using public transport and cut down on carbon emissions.

Chapter 6. Findings and Recommendations

6.1. Main findings of the study

Large quantities of used cooking oil from fast food outlets are available to any business interested in beneficiation of used cooking oil as a biodiesel resource. The main sources of used cooking oil are fast food outlets. This sector still requires proper policy and regulation for disposal of used cooking oil, and to encourage biodiesel production.

The recycling of used cooking oil in Polokwane has proved to be feasible as a sector, but is still at a small scale; and can produce hundreds of thousands of litres of biodiesel, and contribute to the reduction of carbon emissions, and job creation.

6.1.1. Economic benefits of recycling used cooking oil to produce biodiesel

Polokwane still produces biodiesel at a much more small scale. If the municipality can get its policy and regulations for disposal and recycling of used cooking oil right, there could be a possibility for increased jobs and improved economic growth within the Municipality.

As one of objective of this study was to investigate the economic benefits of recycling used cooking oil to produce biodiesel in Polokwane; this study was able to prove that there is greater potential for jobs creation and likelihood of poverty reduction in the surrounding communities in Polokwane. However to realise the economic benefits, the recycling sector policies and regulations would have to be aligned to biodiesel sector in order to be able to completely unlock economic potential of recycling of use cooking oil to produce biodiesel.

6.1.2. Impact of carbon emission on green economy

South Africa currently depends to a larger extents of petroleum diesel in the transportation sector, and this has many implications regarding the carbon emissions caused by petroleum diesel fuel. Most of the diesel fuel is imported

from other oil rich countries. To this end this poses major opportunities for the successful production of biodiesel to supplement the use of petroleum. Then given the availability of used cooking oil in Polokwane, there is high potential to develop a more sustainable project to recycle used cooking to produce a less carbon intensive fuel to supplement petroleum diesel and to achieve green economy objectives.

The production of biodiesel provides an opportunity to decrease the petroleum diesel use. Polokwane city has an air pollution plan that regulates emissions and has control measures in place. This research has proved that recycling used cooking oil is has a direct impact on cutting down carbon emission.

6.1.3. Environmental benefits of using biodiesel

On the green economy and environmental perspective, the recycling of used cooking oil for production and the use of biodiesel provides significant benefits, as the use of more biodiesel leads to less carbon been emitted to the atmosphere. The findings show that in Polokwane this can be fast tracked by putting together supporting mechanisms such as good policy directions and projects that encourages the use of Biodiesel; and that job can be created in projects like the BRT system that uses biodiesel fuel.

6.2. Recommendations

The recycling of used cooking oil to produce biodiesel in Polokwane is economically sustainable at a smaller scale as it is was proved to be cheaper compared to petroleum diesel by users in Polokwane; and produces a less harmful exhaust emission.

Government should play an increasingly major role in supporting small biodiesel sector through a well-coordinated policy framework and work with all interested stakeholders, such as food premises to ensure sustainable supply of used cooking oil; and recyclers of used cooking oil in an attempt to encourage

sustainable production by securing a market for biodiesel in government diesel vehicles; and lastly to link the recyclers with the market for glycerol. All this stakeholders put together may develop a much focused biodiesel sector in Polokwane.

Skills development is also required in the production process; this was highlighted by the recycler, and is a point worth pursuing. It appears there is lack of skills in the biodiesel sector. Therefore as this sector grows, there would be greater need for technicians. In this regard, the technician in the recycling company was trained on the job and he is now in charge of the “only” biodiesel producer in Polokwane. As part of a support mechanism of this sector Polokwane municipality should consider providing bursaries targeting student who want to pursue a career in Biodiesel production as “Technicians”

The future implications of this research provides clarity for the Polokwane municipality to achieve green economy objectives as set out in the Limpopo green economy plans including its climate change response strategy. In addition, an enabling municipal policy specific for recycling used cooking oil may assist in unearthing future opportunities for better investment in recycling of used cooking oil.

In an effort to strive for achievement of green economy in a sustainable way, the whole biodiesel production value chain would need to supported from the point of used cooking oil production up to the point of processing of by products; In this case job opportunities would be created in both up and down stream value chains.

Chapter 7. Conclusion

The research set out to investigate and analyse the challenges in recycling used cooking to produce biodiesel in Polokwane, as well as to find out the role of the government and other stakeholders in the recycling industry; the extent of the benefits derived from recycling of used cooking oil; and the jobs created in the biodiesel industry.

The findings of this research suggests to a greater extent that the recycling of used cooking oil for production of biodiesel, provides valuable benefits in Polokwane and surrounding areas in respect of jobs created in the industry.

This study is consistent with findings from literature on the recycling of used cooking oil to produce biodiesel; and it would be fair to the readers out there that this research concludes that there are job opportunities and socio economic benefits brought about by the recycling of used cooking oil to produce biodiesel in Polokwane. This means, that the production of biodiesel may help with poverty alleviation, boost local economy and contribute to green economy.

Further advancements of the study about the recycling of used cooking to produce biodiesel could bring great economic, and environmental benefits for improved wellbeing of society.

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Appendices

Appendix 1: Informed consent

Research title: Challenges in Recycling used cooking oil to produce Biodiesel in Polokwane

Dear Participant

My name is Humbelani Ramuedzisi. I am a postgraduate student at the University of Witwatersrand: School of Governance.

I would like to invite you to participate as an interviewee in my research study. I am asking you to take part in this study because I am investigating the challenges in recycling used cooking oil to produce Biodiesel in Polokwane.

You have been selected as a possible participant because you/your business are relevant to my study and located within Polokwane. I will ask you about 10 questions related to your area of work or what you do in relation to the green economy sector, such as recycling of used cooking oil; job creation; and environmental issues. The interview will take less than 30 minutes of your time. Your participation is voluntary.

There are no anticipated risks or benefits to your participation. You may decide to discuss your participation with your family or friends. You will be given a copy of this form upon request.

Thank you for participating in this research study.

Yours Sincerely,
Humbelani Ramuedzisi
Cell: 079 490 8529
Email: Humbelani.ramuedzisi@gmail.com

Appendix 2: Research Questionnaires

Questionnaire on the challenges in recycling used cooking oil to produce Biodiesel in Polokwane.

Questionnaire for producers of used cooking oil (fast food outlets, hotels, lodges, hospitals)

1. What type of cooking oil do you currently use?
2. How many deep fryers/frying pots do you have in your business?
3. How much used cooking oil is produced in a day, one week or in a month of operation?
4. What do you do with used cooking oil? Or how do you dispose used cooking oil?
5. Does anyone collect the used cooking oil you generate? If yes how did you dispose it before?
6. How often is the used oil collected?
7. Who collects used cooking oil at your restaurant, factory, or institution?
8. What is the current cost to have this oil removed? How much do collectors charge you to collect used cooking oil?
9. How much do you charge collectors of used cooking oil? How do you measure the cost?
10. What is the agreement in place to have used cooking oil removed at your business?
11. What do you know about recycling used cooking?

Questionnaire for policy and regulations: Polokwane municipal officials

1. What expertise do you have in environmental management?
2. What is your knowledge about green economy and how is the Department/municipality involved in green economy?

3. What green economy policies, plans and strategies exist in the municipality or province?
4. How do you envisage dealing with waste/used cooking oil in local fast food outlets/restaurants?
5. What measures (regulations) are there to make sure waste/used cooking oil does not get disposed illegally (e.g. through sewage drainage system)?
6. What are some of the challenges you have encountered in dealing with used cooking oil? How do you address such challenges?
7. What do you know about biodiesel?
8. What has been your experience in dealing with causes and effects of carbon emissions in Polokwane?
9. What do you know about recycling of waste/used cooking oil to produce biodiesel?
10. What formal businesses do you know, that are recycling waste/used cooking oil to produce biodiesel in Polokwane? If none why are there no businesses doing so currently?
11. What kind of support does government (municipal or Provincial) provide to recyclers of waste/used cooking oil for biodiesel production?
12. What policies are there to regulate local production of biodiesel?
13. What kinds of jobs are being created in recycling of waste/used cooking oil to produce biodiesel in Polokwane?

Questionnaires for policy and regulations: Provincial government officials (LEDET)

1. What is your knowledge about green economy and how is the Department/municipality involved in green economy (role of LEDET in green economy)?
2. What green economy policies, plans and strategies exist in the province?

3. What do you know about biodiesel?
4. What has been your experience in dealing with causes and effects of carbon emissions in Polokwane or in the province?
5. How does the reduction of carbon emissions impact on green economy?
6. What do you know about recycling of used cooking oil to produce biodiesel?
7. What formal businesses (investment projects) are recycling used cooking oil to produce biodiesel in Polokwane?
8. What form of support/intervention does the department provide to recyclers of used cooking oil for biodiesel production? Any incentives or subsidies?
9. What policies are there to promote production of biodiesel in the province?
10. What has been your achievement in implementing green economy policy in the province?
11. What are some of the challenges you encounter as a department in implementing green economy policies?
12. What jobs are being created in recycling of used cooking oil to produce biodiesel in Polokwane? Questionnaire for collectors of used cooking oil

Questionnaire for recyclers of used cooking oil for biodiesel production

1. What is the main aim of your business?
2. What do you know about greenhouse gas emissions?
3. Who supplies you with used cooking oil?
4. What is the current cost of buying used cooking oil?
5. What agreements do you have with suppliers of used cooking oil?

6. How many litres of biodiesel do you produce from recycling used cooking per day/week/month?
7. How economical and sustainable is it to recycle used cooking to produce biodiesel as compared to using fresh oil?
8. What challenges do you have in producing biodiesel?
9. What challenges do you have in recycling used cooking oil?
10. How many people have you employed?
11. What skills do you require in recycling used cooking oil for biodiesel production?
12. What do you do with the by-products of biodiesel?
13. Who buys biodiesel from your business? Or tell me about your customers.
14. What kind of support do you get from government?

Questionnaire for users of biodiesel

1. What fuel do you use for your vehicle fleet?
2. What is your knowledge about biodiesel?
3. What do you think about using biodiesel?
4. Where do you buy biodiesel?
5. How many biodiesel filling stations do you know? And their locations
6. Why do you use biodiesel?
7. How often do you use biodiesel?
8. How much is biodiesel per litres?
9. How much do you spend on biodiesel compared to petroleum diesel?
10. What do you know about greenhouse gas emissions?